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SPECIAL EDITION

POPULAR SCIENCE®

SECRETS OF A DOG'S MIND

contents

06 **An Interspecies Love Story**
We adore our canine companions (and vice versa) through a shared machinery of attachment.

PART 1
THE UNBREAKABLE BOND

1

10 **Finding Home**
How dogs and humans tamed one another and became a team.

20 **Left Alone**
When we are away, our dogs often suffer in solitude. Here's how to help.

26 **Exchanging Glances**
How to read the meaning in your pooch's eyes.

PART 2
HOW DOGS THINK

2

32 **Top Talent**
Many mammalian species are smarter than dogs, but none of them is as good as our pups are at inhabiting our human world.

34 **Decoding the Canine Mind**
Neuroscientists are using sophisticated tools to peer inside our dogs' emotional and cognitive lives. Here's what they've learned.

44 **Canine Enrichment for the Real World**
Work to fight learned helplessness; enable foraging; promote sensory experience; encourage social interaction; and make mental stimulation a part of every day.

50 **What Barks Mean**
How to understand vocalizations.

PART 3
THE CANINE CANVAS

56 | Bits and Bites
News from the canine behavior labs: partners in the pandemic; the human-canine dyad; pups and kids; the extraordinary smarts of working dogs; objects of affection; overcoming insomnia.

58 | How Dogs (and Cats) See the World
Humans get more colors, with greater sharpness and clarity. But dogs have better 360-degree sight.

62 | The Nose Knows
It can sniff out cancer, disease and bombs. Scientists are finding that the dog's nose is a new form of tech.

70 | Ghost Walkers
Understanding the slow-motion slink of your dog in a trance.

72 | Canine Choreography
Learn to read your dog's body language.

PART 4
AUTHENTIC SELVES

78 | This Dog's Got Personality
A pup's breed may tell you something about what they're going to be like, but it's just a starting point.

82 | When I Met the World's Smartest Dog
Chaser wasn't just learning objects by name—she grasped context and the basic structure of human language.

DOGS HAVE BEEN OUR COMPANIONS FOR MOST OF HUMAN HISTORY. IT'S ABOUT TIME THAT WE CHARTED THEIR MINDS.

88 | Rewilding
Imagining the lives of dogs in a post-humans world.

94 | The Five Traits of Dog People
Canine lovers tend to be especially extroverted, agreeable and conscientious but perhaps not as open to new ideas as fans of cats.

an interspecies love story

DOGS AND HUMANS HAVE THE CAPACITY TO TRULY CARE ABOUT ONE ANOTHER THROUGH THE SHARED MACHINERY OF ATTACHMENT AND THE CHEMISTRY OF LOVE. HERE'S HOW IT WORKS.

THE DOMESTIC DOG'S EVOLUTIONARY SUCCESS DEPENDS ON THE BOND THAT'S FORMED WITH HUMAN FRIENDS.

IN ERAS past, it was common to contend that while humans might feel deep emotional love and lifelong attachment, dogs had only instincts and needs. That belief has now been roundly debunked. Canines may not be as clever as humans, but when it comes to the machinery of love, they are well equipped. Here are five linchpins of love, validated by science, that dogs possess in spades.

Dogs have what researchers call a "science of mind," defined as awareness of other minds. That critical ingredient for human friendship and love was once considered a quality of *Homo sapiens* alone. But now we know that dogs are deeply aware of other minds, including their canine compatriots' and ours. This is why dogs are so good at play with other dogs, giving each other a small bow before embarking on a rough-and-tumble round. Dogs can detect emotion in the human voice as well as read happiness and sorrow on the human face. They watch us intently. And while dolphins and even pigs may have more innate smarts, dogs have thrived on Earth by looking to human friends to solve their problems and provide their creature comforts, based on emotional attachment alone. We know that dogs are "attentive to others' attention," says Alexandra Horowitz, PhD, a psychologist and animal behaviorist at Barnard College in NYC, "which is very cool." That's the type of skill used by people known for their social smarts. "That's probably why dogs slip nicely into human society," she adds.

Dogs and humans share the bonding hormone, oxytocin, which is integral to their relationship with one another. Also called the "love hormone" or the "cuddle hormone," this biomolecule is produced in the hypothalamus, an important center for emotion in the brain. No doubt, you've heard that mothers get a surge of oxytocin when breastfeeding their babies. But we also get a burst while cuddling our dogs—and our dogs produce oxytocin in return. Scientists have measured spikes of oxytocin in mothers and infants and in newly enamored couples, says Clive Wynne, PhD, founding director of the Canine Science Collaboratory at Arizona State University. Wolves hand-reared by humans did not show the same hormonal surge.

Many dogs apparently have DNA coded for "friendship," according to Wynne—who, with colleagues, has identified three genes that mutated as wolves evolved into dogs. The same genetic mutation, sometimes seen in humans, has been traced to Williams syndrome. People with Williams syndrome have a variety of deficits, Wynne told me, but their most notable feature is exuberant friendliness toward others—a trait we see in our canine pals. Wynne was worried that people with the syndrome or their families would be offended, but, he told me, "they embraced the news."

Dogs' brains are structured for attachment with humans, scans using magnetic resonance spectroscopy have shown. Gregory Berns, PhD, a neuroeconomic professor at Emory University in Atlanta, who describes this research himself in "Decoding the Canine Mind" (page 34), has trained dogs to lie still in MRI scanners while awake: He has been able to activate the reward center in the dog's brain by signaling they will receive a piece of hot dog. But brain activity was even greater when he signaled that their human was nearby. (Other researchers have documented that the hearts of dog and human companions beat in synchrony when their bond is strong.)

Dogs and humans can meet one another's gazes and respond to one another's body language. This intimate interspecies language, which is covered throughout this issue, has evolved over millennia.

The accumulated evidence shows that dogs love us and we love them back. For most owners, all this is just confirmation of what they have long known: that the bond they feel with their dog is powerful—and real. For the skeptics among us, the science has spoken. Perhaps it's time to get a dog of your own!

Pamela Weintraub
EDITOR

PART 1

THE UNBREAKABLE BOND

AN INDELIBLE RELATIONSHIP MEANS AN ENDURING ATTACHMENT BETWEEN HUMANS AND THEIR DOGS.

CANINES VENTURED TOWARD TAMENESS WHEN A FEW WOLVES LEFT THE WILDERNESS TO BENEFIT FROM HUMAN RESOURCES AND LARGESSE.

finding home

HOW DOGS AND HUMANS BECAME A TEAM.

BY KAT McGOWAN

A BLACK-AND-WHITE Boston terrier named Chevy, as sleek and dapper as a seal in a tuxedo, trots crisply into the soundproof testing room. His jaunty confidence will fade quickly as a team of researchers subjects him to a series of psychological experiments that will daunt, dismay and ultimately baffle him. Poor Chevy is about to be gaslit for the sake of science.

This spiffy little terrier is volunteer No. 1 on day No. 1 of an ambitious project, launched by Harvard University evolutionary neuroscientist Erin Hecht, PhD, to answer basic questions about what dogs do and why they do it. She plans to collect data on the psychology and behavior of hundreds of them across all breeds over many years: how easily they make friends, how well they behave, how they feel about vacuum cleaners. Four video cameras document Chevy's reactions

UNDER STRONG ENVIRONMENTAL PRESSURE, THE DOG'S BRAIN EVOLVED TO MESH WITH THE HUMAN WORLD.

to a researcher's precisely scripted maneuvers. In a room next door, the rest of Hecht's team watches through a two-way mirror.

After some preliminary scratches and pats, Harvard undergraduate Hanna McCuistion gives Chevy a few treats, then places the next one under a glass jar. He sniffs eagerly at it, then gazes beseechingly at her, cocking his head back and forth, turning the dial up to maximum cute. It's a classic move, Hecht explains: Faced with a difficult situation, a dog quickly turns to a human for help. After 20 seconds, McCuistion lifts the jar for him, and he gobbles up the snack.

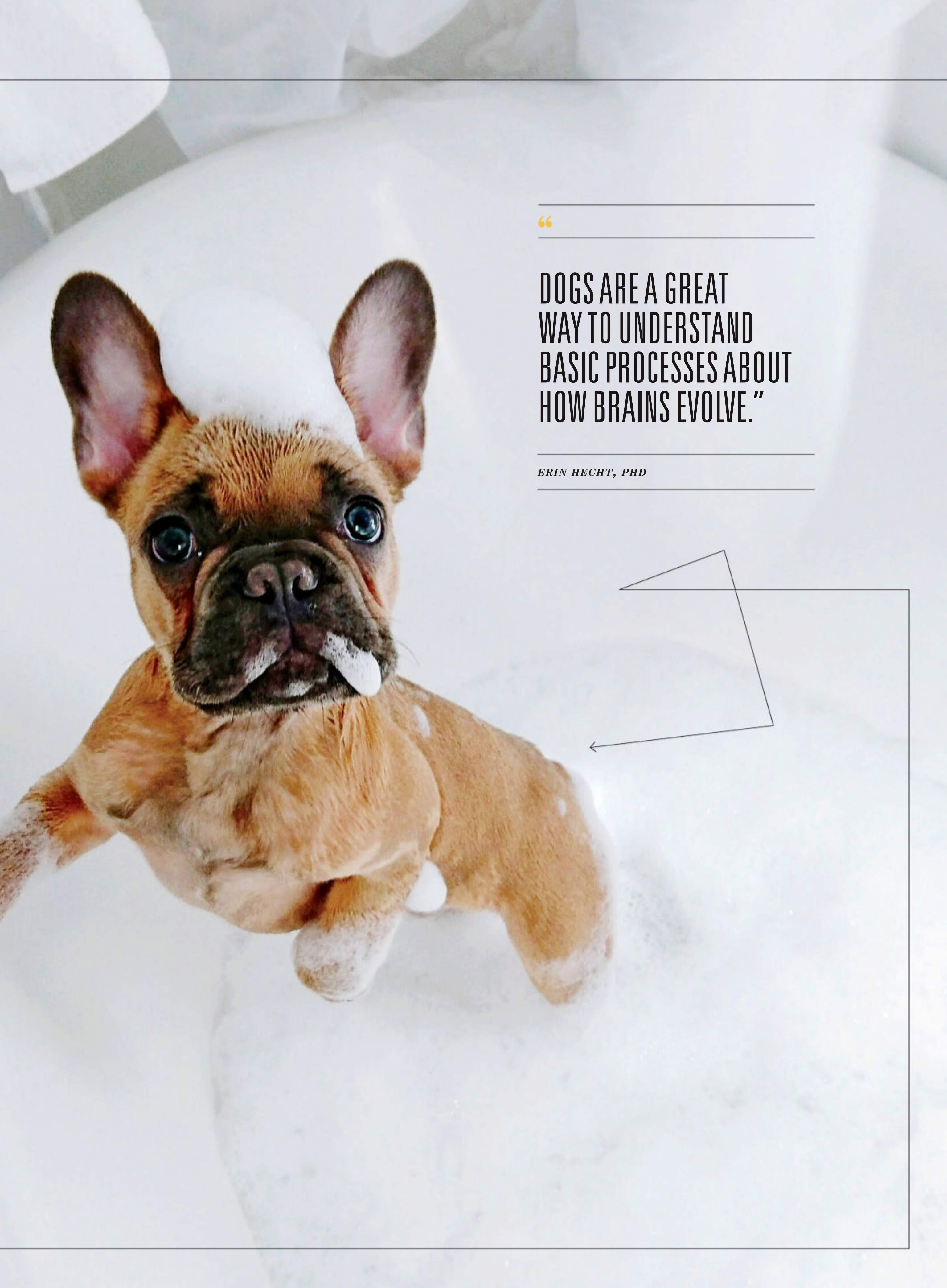
A few more simple tests, then she ushers Chevy into a large wire cage and leaves him alone in the room. He fidgets and softly whimpers. Researcher two, Stacy Jo, soon enters, but she turns away, facing the wall for a few long moments while Chevy stares fixedly at her back. Without making eye contact or speaking, she approaches his cage and sits precisely 12 inches in front of the door, eyes on his chest. Chevy stands stock-still, ears perked, trembling slightly. Nonscientifically speaking, this dog is completely weirded out. From the other side of the mirror, the scene is both agonizing and hilarious, like the world's most awkward date. Heroically, Jo keeps a straight face.

The data from these tests—plus DNA samples—will ultimately give Hecht new hints about what changed in dogs after their wild leap into tameness. Biologically, they're almost all wolf; technically, they're the subspecies *Canis lupus familiaris*, but they are fundamentally different from their forebears. You can hand-raise a wild animal to be tame, and that individual might be gentle and mild-mannered. But domestication is a different story. For dogs and other animals who live with us, tolerance and trust are engraved in their genes and in their brains.

Hecht's study is a way to get insight into the broader subject of how neural matter evolves under strong environmental pressures—in this case, the very peculiar circumstances of living with, depending on and loving another species. "I'm interested in dogs, both for the sake of dogs and for what we can learn about humans," she says. "But more generally, dogs are a great way to understand basic processes about how brains evolve."

She is among a wave of investigators puzzling out exactly how these fur balls got to be our face-licking, tail-wagging No. 1 fans. We prefer to think that humans wrote the story of domestication: Some galaxy-brain hunter-gatherer kidnapped a wolf puppy and then shaped a new species of prey-sniffing partner, watchdog and companion. But increasingly, most researchers think that dogs were the original authors of this tale. Long ago, some wolves hitched their destiny to ours, the first step in a love affair that entangled both our fates.

Though archaeology can help us pin down the when and where of dog domestication (current thinking is that it happened at least 15,000 years ago, in Europe, Asia or both), bones are mostly



“

DOGS ARE A GREAT WAY TO UNDERSTAND BASIC PROCESSES ABOUT HOW BRAINS EVOLVE.”

ERIN HECHT, PHD

THE GRAY WOLF IS THE LARGEST CANINE FOUND IN THE WILD.

silent on the how and why. By studying other canids, like foxes and wolves, and by analyzing dogs' genes, behavior and brains—their sweet, friendly, trusting brains—researchers are developing new ideas about how the big bad wolf became the precious little pooch. Some argue their social intelligence is what makes them extraordinary; others point to their devotion and deep craving for human interaction.

As the first domesticated species, dogs are also a model for how other mammals—including us—got that way. Scientists see, in their genes and minds, hints about our own unusually tolerant nature. During much of the human journey from just another primate to world-conquering hominid, our four-legged pals have been right by our side. They are our familiars, our echoes, our shadows, and when we look into their eyes, we often glimpse a new image of ourselves.

How Canine Brains Evolved

One night in 2011, Hecht and her miniature Australian shepherd, Lefty, were on the couch, watching TV, when a show came on about the legendary Belyaev foxes. Dmitry Belyaev was a Soviet geneticist in the early 1950s, a time when Moscow suppressed genetics research, viewing it as a product of the imperialist West.

Unable to study openly in his chosen field, Belyaev hit upon an ingenious plan. He could experimentally tame foxes raised for their coats. Since animals kept by humans tend to reproduce more frequently, he would officially be accelerating Soviet fur production. But the project would also sneak in some science. His theory was that just by breeding for tameness, what's now described as the "domestication syndrome" would emerge: more juvenile behavior and physical changes such as white splotches on the belly and face, floppy ears, shorter snouts and smaller teeth.

The research got going in earnest in 1959, in Siberia. Belyaev's partners selected animals that were simultaneously less fearful and less aggressive (these traits typically go hand in hand), then crossed them. Just four generations later, in 1963, when collaborator Lyudmila Trut approached a fox cage, one of the kits wagged its tail at her. By 1965, a few juveniles were rolling on their backs and whimpering for attention, just like puppies. The researchers also kept a population of randomly bred control animals and, later, a strain of extremely fearful, combative ones. The landmark study continues to this day.

Hecht already knew this history, but the show sparked a realization: Nobody had analyzed the foxes' brains. Usually, humans breed goats or sheep or other domesticated animals for many traits, including temperament, size and coat color, all of which might leave inadvertent marks on the mind. But differences between tame and regular fox noggins could be due only to selection in behavior—what Belyaev and Trut did. They'd stand out like a beacon, illuminating exactly which

> THE ESSENCE OF A DOG IS REDUCED FEAR AND THE UNCANNY ABILITY TO READ OUR MINDS.

circuits or new neurochemistry turned a cringing, snarling little vixen into a sweetie. And they'd point the way to a deeper understanding of how evolution can remold a mind.

"On the one hand, there's the basic question of how brains evolve," Hecht says. "And the more specific question—which is, 'What are the neural correlates of domestication?' Surprisingly, we don't know." At least, not yet.

Whatever she found could also provide insight into a few emerging theories. One, articulated in 2005 by anthropologist Brian Hare, PhD, and psychologist Michael Tomasello, PhD, proposes that back in the day, some unusually plucky wolves began hanging around human settlements to scrounge for scraps, giving rise to a less timid subpopulation. It would thousands of years of human breeding to complete the process of domestication. Still, without fear holding them back, these proto-pooches could repurpose their existing social skills, to understand and communicate with us. That's the essence of a dog, Hare and Tomasello argue: reduced fearfulness enabling advanced social cognition, that uncanny ability to read our minds.

The proof is that pups just get us, without any teaching. Chimpanzees, for instance, struggle to follow a pointing gesture, but most mutts understand it right away. That thing Chevy did—looking to McCuistion to solve his problem—is another example. He intuitively knew how to ask for help.

In the recesses of fox brains, Hecht might see signs of whether this theory or others hits the mark. She emailed Trut, who sent a few dozen specimens from recent generations of the Russian foxes, and used MRI to measure the relative size and shape of various structures in their brains.

Hecht saw changes in the parts of the limbic system and prefrontal cortex involved in emotions and social behavior. These data could support the domestication hypothesis, but don't rule out other competing ideas either. This initial finding mostly confirms that the brain regions you'd expect to be different are, in fact, different. So for a finer-grained picture, Harvard postdoc Christina Rogers Flattery, PhD, is adding another dimension to the analysis, shaving the fox brains into tissue-thin slices and staining them with a dye that reveals their neurochemistry. She's looking at the pathways of neurons that make the neurohormone vasopressin and at a serotonin subsystem, both of which are linked to aggression. She's also investigating cells that make oxytocin, which promotes social bonding. There are many possible neural modifications that could lead to tame behavior, such as the boosting of circuits involved in social bonding

IN FOUR GENERATIONS, RUSSIAN SCIENTISTS TAMED THE FOX.

or the tamping down of systems that trigger violent attacks. By weaving together Flattery's investigation with brain scanning, plus genetic insights from a third collaborator—geneticist Anna Kukekova, PhD, at the University of Illinois at Urbana-Champaign—the group might identify a grand unified brain theory of tameness...or at least its neural-circuit diagram.

Breeds Apart

As Chevy responds to his prompts, he's representing not just himself but also his breed. While we all have the sense that pit bulls and Pekingese and Irish wolfhounds have distinct personalities and skills, Hecht hopes to pin down those differences. It's yet another way to explore how selective pressure shapes a brain. In a recent paper, Hecht analyzed MRI scans from 33 breeds, finding that a Weimaraner's noggin has extra terrain devoted to visual processing, while that of a basset hound is primed to analyze smells.

In that same paper, Hecht also looked at a Boston terrier's brain, which was loaded up with networks related to social activity. Chevy seems to be no exception. With the tests complete and DNA sample collected, he bursts into the waiting room, zipping around to greet each person, a tiny whirlwind of bliss and joy.

As the little guy gazes into each human's eyes, little bursts of oxytocin likely erupt in his brain (and in each of our heads as well), findings from a 2015 study suggest. The hormone promotes bonding, which might be why canines are so good as therapy or emotional support animals for people who have survived trauma.

This swirl of friend-making ecstasy has inspired a rival origin theory that focuses on feelings rather than cognition: "their hearts, not their smarts," in the words of Clive Wynne, PhD, behavioral scientist at Arizona State University. With collaborators Nicole Dorey, PhD, and Monique Udell, PhD, at the University of Florida and Oregon State University, respectively, Wynne proposes that the essence of dog identity has to do with emotional connection—love, to use a word rare in science. "It's kind of obvious," Wynne says. "They're amazingly affectionate. It's just been avoided, in part because it doesn't sound serious enough to be a topic of investigation."

The researchers happened upon this line of inquiry in 2008, when they set out to establish further proof for the domestication hypothesis. But their head-to-head study of dogs and wolves found quite the opposite. Well-socialized wolves from a research institute in Indiana easily followed human pointing gestures, while some shelter dogs who'd had little contact with people did not. (Later studies showed that coyotes and even some hand-reared bats can do it too.)

Another surprise came from a simple test measuring the amount of time each canid hangs around a familiar person. Dogs stick close; wolves—even friendly, hand-raised ones—don't. Dogs, they reasoned, have a unique drive to bond, even with members of another species. Every pup is born with the capacity, including some 750 million stray "village dogs" worldwide. Incidentally, that ability to form interspecies bonds also explains why livestock breeds can be so vigilant guarding sheep or ducks.

More recently, Princeton University evolutionary biologist Bridgett vonHoldt, PhD, discovered what might be the root of this affection. In the DNA of dogs, she and her team found a marker of evolutionary pressure on chromosome 6. In humans, equivalent mutations cause Williams syndrome, a developmental disorder that leads to indiscriminate friendliness, or hypersociability. "I like to think that, in a very positive, adoring fashion, maybe dogs have the canine version of the syndrome," she says. Here too, the change initially arose in them, rather than through something we humans intentionally did.

Exactly how a few gene changes could transform a canid into everyone's BFF is unclear, and for unknown reasons, the tendency is stronger in some dogs—*cough*, Labrador retrievers—than others. In one of Hecht's tests, known as the "empathy task," researcher McCuistion pretends to smash her thumb with a hammer, yelping as if she is in pain. Some animal subjects leap into the person's lap, licking the faux wound. Chevy pretty much ignores her.

Nonetheless, studies of different kinds of canines raised under

!

THE ESSENCE OF DOG IDENTITY HAS TO DO WITH EMOTIONAL CONNECTIONS.

OUR PET DOGS TRY TO ADJUST THEIR SCHEDULES SO THAT THEY SLEEP WHEN WE DO AND SPEND AS MANY WAKING HOURS AS POSSIBLE IN OUR COMPANY.

identical conditions hint that neither hypersociability nor social-cognition theories like the domestication hypothesis answer every question. Starting a decade ago, teams at Stockholm University and the University of Veterinary Medicine at Vienna's Wolf Science Center began raising groups of dogs and wolves in the lab. In their first months, both sets of puppies are with people 24 hours a day; after that, the animals live in packs, with extensive human companionship.

These experiments indicate dogs aren't just wolves with better social skills. For one thing, hand-raised wolves are quite affable; they happily greet their caretakers and will go for walks on a leash. In 2020, the Stockholm team noted, to its surprise, that a few of the puppies intuitively comprehend "fetch" gestures, just like dogs do.

In fact, research out of the Wolf Science Center has found that in some situations, these wild animals are actually more tolerant than dogs: Given food to share, dogs keep their distance from one another. Wolves bicker and snarl at first, then eat peacefully side by side. In one study, pairs of wolves or dogs must cooperate to retrieve a piece of meat; wolves work together effectively, but dogs are "abysmally bad," says investigator Sarah Marshall-Pescini, PhD. When she tested wolf-human and dog-human cooperation partners, the pattern became clearer. Wolves aren't afraid to take the lead, while dogs hang back and wait for a human to make the first move.

These unexpected findings led Marshall-Pescini toward yet a third theory of self-domestication: Maybe the shift wasn't a new social skill or expression of love but, rather, a novel conflict-management strategy. Humans probably would've killed bold, assertive wolves as a threat. But they might have tolerated deferential, avoidant proto-dogs who skulked around the camp, hoping for a handout. (Aggressive varieties are probably a recent phenomenon, the result of dog fanciers in the 18th and 19th centuries who created nearly all modern breeds.)

DOGS LOVE IT WHEN THEIR HUMAN GIVES THEM TREATS AND PRAISE.

Marshall-Pescini's group is looking at village dogs, to understand more about canine social structure and how they respond to humans. Compared with our pets, these free-ranging animals are probably far more similar to the early dogs that were their long-ago ancestors—some friendly, some shy, all of them in an uneasy, ambivalent relationship with the hairless apes they rely on to survive.

Domesticating Ourselves

Lurking around the edges of this research like some wolf sneaking beyond the campfire, is the idea that we, too, may have domesticated ourselves. That's one reason Hecht hopes to find a signature of tameness; if she does, she can look for the same

pattern in the brains of house cats as compared with wild ones and in our gray matter in contrast to apes. Anthropologist Hare's version of this account of human origins, "survival of the friendliest," posits that just like dogs, we became more trusting and tolerant of one another in our long-ago past, which in turn allowed us to develop superskills in communication—language is one obvious example.

The notion of human self-domestication has bumped around at least since Darwin's time, but today there's actually evidence, points out primatologist Richard Wrangham, PhD, of Harvard's department of human evolutionary biology. In addition to our unusual (for primates) tolerance of strangers and our long adolescence, we show some of the physical traits associated with domestication syndrome. Compared with our hominid relatives, we have shortened faces and smaller teeth. In 2014, Wrangham and collaborators even proposed a possible biological mechanism in neural crest cells, which help shape many of those body parts during embryonic development. The implication, implausible as it may seem today, is that our species evolved to get along peaceably with one another.

In December 2019, a European group found that the gene BAZ1B, located in the Williams region, influences facial shape by directing such cells. It could explain part of the human self-domestication story, Wrangham says.

Back in Hecht's lab, a new volunteer named Coda (also a Boston terrier) runs through his tests. For one task, McCuistion places a treat on the floor, says, "No! Don't take it!" and then closes her eyes. Dogs know what eyes closed means, so at this point, most snatch the treat. Not Coda. As his owner points out, he's always a very good boy. He sneaks a look at it, licks his lips, then stares glumly into space, avoiding conflict, as is his doggy destiny.

Over on the other side of the two-way mirror, the humans are absorbed in this drama. "Goooood *boy*," someone says. Even after McCuistion finally gives him permission to eat the snack, he still stands there, looking at her sadly. A chorus erupts in the waiting room: "C'mon, Coda, take it!" We can all see his desire, feel his restraint. It's enough to make you wonder who, exactly, evolved to read whose mind.

To look upon a dog is to aspire to the best in ourselves—to find what it takes to live in harmony, to understand one another, to replace fear and aggression with love and loyalty. Perhaps that's why dogs are so thoroughly delightful. They are a living reminder of a better version of ourselves. His afternoon of testing over, Coda takes the treat and shakes himself. His human comes into the room, and he leaps onto her lap, panting happily, staring deep into her eyes as she looks directly into his.

WHEN A DOG IS BORED AND STRESSED, HE MAY CREATE HIS OWN FORM OF ENTERTAINMENT.

left alone

WHEN OWNERS ARE AT WORK OR AWAY, THEIR CANINE COMPANIONS MAY SUFFER IN SOLITUDE. AN EXPERT TELLS YOU WHAT YOU NEED TO KNOW ABOUT DOGS' SEPARATION ANXIETY.

EDITED AND CONDENSED BY MARK TEICH

FOR ALL the love that dogs give us when we're with them, some pups have a flip side: When we're *not* with them, they become nervous wrecks. This state of heightened, fretful loneliness certainly isn't good for their physical and mental health, and it's no picnic either for neighbors who hear their hours of loud lament.

To help you understand the roots of dogs' separation anxiety and what to do about it, we interviewed canine cognition expert Clive Wynne, PhD, an ethologist at Arizona State University.

Q / How exactly does separation anxiety reveal itself in dogs?

Generally, any undesired behavior in an animal left alone reflects separation anxiety. In dogs, we're talking about inappropriate toileting, such as urination and defecation in the home; barking until they're hoarse; scratching at doors—these are the major ways people find out they've got a problem. Or perhaps the neighbor comes around and says, "Hey, you know, your dog was barking all day. It's driving me crazy," and you had no idea about this, because you weren't there. In extreme cases, the animals go completely crazy and try to bite their way out of the room that they've been left in, chewing on the door and door frame. Ultimately, the problem is defined by human observers who find the dog is doing something they prefer it wouldn't do—and generally, these behaviors indicate that the animal is in distress.

Q / How common is this in dogs?

It is the most common canine behavioral problem reported in the United States, and it's the most common behavioral reason that dog owners visit a veterinarian.

Q / What are the causes? Is this something that occurs naturally in some dogs, or are there human behaviors that exacerbate it?

People often talk about it as an abnormal reaction to normal circumstances, but I say it is often an understandable reaction to unreasonable circumstances. I think people leave their dogs alone far too much. We bring them into our lives, we love them because they are so affectionate and so loving, then we treat them as if they're gadgets, as if they're AI boxes, like Alexa, smart speakers we just talk to that answer us back.

But AI boxes aren't lonely when we don't talk to them for hours, while our dogs are living, vibrant beings, and they need company—not every moment of the day, but they need more company than people give them. Before the pandemic, when we went out and left them alone, we often pushed them beyond a reasonable limit. Going to work, with commuting time, we could be leaving them alone eight, 10, 12 hours a day, and that's just unreasonable. In some countries, like Sweden, it's not even legal—there are laws against leaving a dog alone for so long. So we shouldn't be surprised that our animals react; a dog just can't cope with being left alone for such a long period of time. As people who live with dogs, we should try to structure our lives so that we're not away for too long.

We can all be unsettled by changes in our routines, and that's as true of our dogs as it is of us. Generally speaking, we recover from changes in our lives. Dogs, like most people, are responsive and adaptive to change, and they can usually cope. But obviously, every dog's an individual, and some dogs do seem able to cope fairly well with being left alone, while others, for whatever combination of genetic and environmental reasons, overreact if we're out of the house just one or two hours, which they ought to be able to handle. Some people love their own company, and some people hate it. That's as true of dogs as it is of ourselves. It all depends on a combination of individual factors in the dog's personality.

Q / In the more extreme cases, how can we know whether the dog is experiencing mere separation anxiety or has advanced to full-blown depression?

Behavioral experts can help. There's a whole range of people who call themselves dog behaviorists. If they're any good, they won't offer advice over the phone; they'll come to the home so they can understand exactly what goes on there and give advice that's concrete, in the environment where the animal is.

The problem is, there's no regulation of that profession whatsoever, so you

DOGS LEFT ALONE MAY WAIT BY A WINDOW OR DOOR FOR THEIR HUMANS FOR HOURS ON END.

can go to a “behavioral expert” who is a complete waste of time and money. On the other hand, you could go to one who’s really good.

There’s high variability in expertise in people who call themselves dog behaviorists, and you need to watch out, because unlike with veterinarians, where there is a qualifying exam and certifications, there’s no equivalent, formal ensured expertise among dog behaviorists. There are certain certifications they can get, like the certification for professional dog trainers (CCPDT), which is fairly reputable. And there are a few others, so do your due diligence.

Some veterinarians are expert dog behaviorists. Most vets are not that well informed about behavior, but some are.

Q / How do you determine which vets are actually good on behavior?

As in human medicine, veterinarians can specialize. And if they specialize, they are board-certified. You can find them on the internet, but there aren’t that many. I think there are 3,000 to 4,000 vets in the United States, and only a few dozen are board-certified vet behaviorists. If you’re lucky enough to have one of those in your

5 ways to keep your dog happy when you go out

The truth, says Clive Wynne,PhD, is that we may be stressing our dogs’ bodies and brains when we leave them alone for more than a few hours, and they can become increasingly agitated as the hours pass. Fortunately, there are many ways to keep this from happening. Here are five strategies to prevent or reduce your dog’s separation anxiety.

LIMIT TIME ALONE.

If you work at home, it’s fine to go out for a while, be it for a business meeting or to hit the town with a loved one or friends. But if you’re going to be gone for a bigger part of the day, at least have one visit, at the midpoint, from a dog walker so that your pet can have some company, get out to smell the roses, see the scenery, have some exercise and relieve itself.

An alternative is to have a friend come over with their canine companion (or even their cat, if your dog has been trained for that) for a playdate with your dog. “Keep in mind that our dogs are highly social beings, and it’s not only our company that they value but the company of other people and other species,” says Wynne. If you commute to an office for a full day’s work, up it to at least two visits from a dog walker or friend—or consider a good doggie day care center.

VARY THE TIME THAT YOU SPEND AWAY.

The standard advice for those who work away from home all day is to leave home and come back at the same time every day, since adapting to a schedule helps your dog to stay calm. But if you work from home, Wynne thinks it’s useful if your comings and goings are more unpredictable so that your dog can basically say to itself, “I see—they go away, and though it’s hard to say when, they will always come back.”

DON’T MAKE A BIG PRODUCTION OF YOUR COMINGS AND GOINGS.

“Resist the temptation to make a big production of it when you leave or come back,” Wynne advises. “It’s generally a better idea to slip away quietly, without making a big fuss—likewise, when you return.” This will simply lower the temperature of your being away, which will help keep your dog stay calm.

GIVE YOUR DOG A FOOD TOY BEFORE YOU LEAVE.

The less time your dog is thinking about missing you, the better. A food toy can occupy your dog’s mind, keeping him busy and focused on something other than your absence.

BEFORE YOU LEAVE HOME AND WHEN YOU RETURN, SPEND QUALITY TIME.

Pet your dog, feed it, let it sit on your lap; take a walk with and play with your pup. Walking, especially, serves multiple functions, allowing your pet to empty its bowels and bladder, using up energy to help maintain calm and, of course, showing that you love and value your dog.

GIVING YOUR DOG A TASTY DISTRACTION (SUCH AS A TOY STUFFED WITH TREATS) WHEN YOU LEAVE CAN PREVENT DESTRUCTIVE BEHAVIOR IN YOUR ABSENCE.

OF ALL CANINE VETERINARIAN VISITS, 20% TO 40% ARE RELATED TO SEPARATION ANXIETY.

COLLEGE OF VETERINARY MEDICINE, UNIVERSITY OF ILLINOIS

neighborhood, they would be an excellent person to call on.

One advantage of having a behavior expert who's also a vet is that, if it's called for, they can prescribe medication that will help, such as an antidepressant.

Q / You mentioned the pandemic, suggesting that because we're home more now, we may not be leaving our dogs alone so much. Will their anxiety increase when we go back to work, and how can we avoid that?

With the pandemic, many of us are working at home full-time, and it is easy to spend every minute of every day with your dog. This has been one of those tiny silver linings of pandemic life, because our animals are so much happier that we're with them all day.

But it's actually healthy for pets that we go out without them sometimes—even if we could take them with us—just so they can get used to this. They need to know that this separation is a normal part of life and not something to worry about.

To get them ready for the transition out of the pandemic, we should start getting our dogs accustomed to the fact that we can leave the house and go places without them, which many of our dogs may have forgotten over the course of the past year. (For more ways to keep your dog's "home alone" stress to a minimum, check out the sidebar, opposite.)

exchanging glances

YES, YOUR DOG IS MAKING PUPPY EYES AT YOU. SOMETIMES SCIENCE CONFIRMS THE OBVIOUS.

BY SARA CHODOSH

HUMANS AND DOGS HAVE WHITE IN THEIR EYES, TO CREATE CONTRAST THAT AIDS IN COMMUNICATION.

DOGS ARE a lot like babies that never grow up. This is both a great strength and a huge annoyance, mostly because they can't talk. Researchers who study infant learning and behavior have to rely on other cues, like how long subjects look at an object, because asking them questions is just a big waste of time. Dogs are the same, and that makes it very difficult to come to definitive conclusions about their behavior and what it means.

We know, for example, that humans interpret dogs' facial expressions as conveying certain emotions and that doing so affects our behavior. Pups who raise their inner eyebrows—making those big, sad eyes up at you—are more likely to get adopted from shelters. That's probably because we find them more adorable when their eyes are large and round, like a baby's. The biological response to infantile features is fairly hardwired into us, though that doesn't make things any less tragic for the poor doggies who didn't manage to look cuter in their cages.

What we don't know is whether dogs are changing their facial expressions *intentionally*. Plenty of animals look sad when they're sad, humans included, but they look that way regardless of whether anyone is there to see it. If an animal specifically puts on an expression when there's someone paying attention—but not when they're alone—*that's* communication. And dogs seem to do that.

Not long ago, animal psychologists found that pups made more expressions when their owners were looking at them than when their humans' backs were turned. And that happened whether the dogs were offered food or not, so it seems that this isn't just about the pupper being generally excited. Food, as it turns out, has been found to be more arousing to dogs than human contact, so long as the person doesn't say anything (some humans are the same way). If facial expressions are just an involuntary response to excitement, dogs should make the same number of expressions when presented with food as they do under a human's gaze.

The fact that they don't—that they actually make more eyebrow movements when a human is facing them—might seem obvious. But it seems that way only because we assume a lot about our pets. It's easy for us to impose our own feelings on a sweet, loving animal who can't correct our assumptions, but that doesn't mean we're right. Lots of pet owners attribute humanlike emotions to their canine companions, even when the evidence suggests they're mistaken. People often think that their dogs and cats feel guilt when they've done something wrong and punish

WE FEEL OUR DOGS ARE TRYING TO TELL US SOMETHING. NOW SCIENCE HAS STEPPED IN TO CONFIRM THE MESSAGE.

DOGS ARE FAR MORE ATTUNED TO HUMAN BEHAVIOR THAN CHIMPS AND WOLVES.

them accordingly, but studies have found that this is just an expression that pets put on, to appease their owners. It's not real guilt, and they don't actually realize what they've done wrong. So while we think we're punishing them for something they know they've done, they may just feel we're punishing them arbitrarily.

Not all anthropomorphizing is dangerous, of course. It's just important to figure out what's fact and what's fiction. Our seemingly "obvious" intuitions about our best friends can be wrong, and that's why canine research exists. Even if it seems like science is just confirming the obvious, we still have to confirm it.

So yes, it's a little unsurprising to learn that dogs intentionally make eye contact with us. Dogs evolved alongside humans, and it seems natural for them to be under selective pressure to develop traits that allow the two species to communicate—or, at least, to reflect the desires of the people they live with. After all, it was our desire for nonaggressive companions that caused dogs to evolve away from their wolf ancestors and become increasingly like eternal puppies. They make eye contact with humans that gives both parties a feel-good oxytocin boost, while their wolf compatriots avoid that type of bonding. And if a person meets a dog's gaze, then points or gestures to a hidden object, the furry friend is able to find the item successfully. Our canine buds are highly attuned to our behavior. It follows that humans might also have taken a shine to that eyebrow-raising, eye-widening gaze we so appropriately call puppy-dog eyes, thereby unintentionally causing dogs to make that expression more often.

Over time, that selective pressure may have given dogs the ability to change their expressions in order to communicate rather than accidentally conveying emotion. We don't know for sure that wolves don't do this—and as social animals trying to survive in the wild, they may very well do it better than dogs or, perhaps, just differently. After all, primates evolved their expressive faces for each other, not for humans. If wolves have the ability too, that would suggest that it evolved out of a social pressure having nothing to do with people. The research into canine eye expression neither confirms nor denies any of that—its focus is the human-dog relationship and nothing else. Dogs seem to use more facial expressions when a human is paying attention to them. What that means is another question entirely.

Of course, it *feels* like your dog's trying to tell you things—and in many cases, they are. It's just important that we bother to confirm the intuition using actual evidence. Because you know what happens when you assume: Sometimes you get it wrong.

DOGS HAVE FACIAL MUSCLES THAT HELP THEM SPEAK TO THEIR HUMAN FRIENDS.

interpreting your dog's facial expressions

BY LEARNING HOW TO READ YOUR DOG'S EMOTIONS, YOU WILL STRENGTHEN YOUR BOND AND BETTER UNDERSTAND WHAT YOUR FURRY FRIEND IS TRYING TO SAY.

THE HEAD TILT

There's nothing cuter than a good doggie head tilt, especially when a pack of dogs tilt in tandem. But does it mean your dog is confused or following your train of thought closely? When you talk to your dog about the meaning of life and he tilts his head to the side, it's similar to the human nod: It shows that he's engaged and curious (and dogs know that the meaning of life is plenty of naps, treats, walkies and cuddling). He's not only listening, but he's prepared to read between the lines (if he could only read). The head tilt tends to encourage humans to keep talking, and dogs lap up the attention.

THE GUILTY FACE

It's instantly recognizable to attentive dog owners: You come home from work, and your dog is sitting there with a bowed posture; her chin tilted downward; and big, sad, sorrowful eyes. Even if you haven't spotted the ruins of your couch yet, you know she's done something very, very bad. Some dogs have even been known to throw themselves on their backs and play dead. However, researchers have concluded that the hangdog expression actually reflects a fear of scolding rather than the more complex, human emotion of guilt. (Except we dog parents know that our pups understand exactly what they did wrong!)

THE SMILE

Whether it's ear-to-ear or more Mona Lisa, dogs do smile: mouth open and curved up at the corners, tongue lolling out. Dogs typically use body language to express happiness; their ability to smile is an adaptive, evolutionary behavior related to living with humans. Humans respond to a smiling face. A dog's smile is a brilliant example of their ability to observe human behavior and manipulate us with charm. When a dog smiles, humans react positively, with affection, treats and excitement. Plus we automatically smile back. It's a win-win situation.

THE WORRIED LOOK

In the wild, dogs (or their ancestors, wolves) would never let others see them sweat. But as domesticated creatures (and divas), dogs have evolved facial movements to communicate specifically with bipeds in ways that we understand; they use different body language when communicating with other dogs or strange animals. If their human is doing something that's concerning, such as packing a suitcase, a worried dog will raise his eyebrows, wrinkle his nose, make his eyes bigger and let his ears droop. They know what they're doing: In fact, over time, they had to adapt their muscles to raise their eyebrows. And when our dogs look worried, we respond by offering comfort and reassurance (even if we don't cancel our vacation).

THE SUBMISSIVE GRIN

Resembling a grimace more than a grin, dogs use it to great effect. The submissive grin shows a lot of teeth, with the top and bottom lip raised and retracted, as if they've looking in a mirror to see if there's food caught in their incisors. This grin may be mistaken for aggression, but it's the opposite. It's a deferential expression that's used when a dog wants to appear friendly—or when they know they've done something you don't like and are a little embarrassed. Denver, the internet-famous yellow Lab, uses it to great effect when he's asked if he did something naughty.

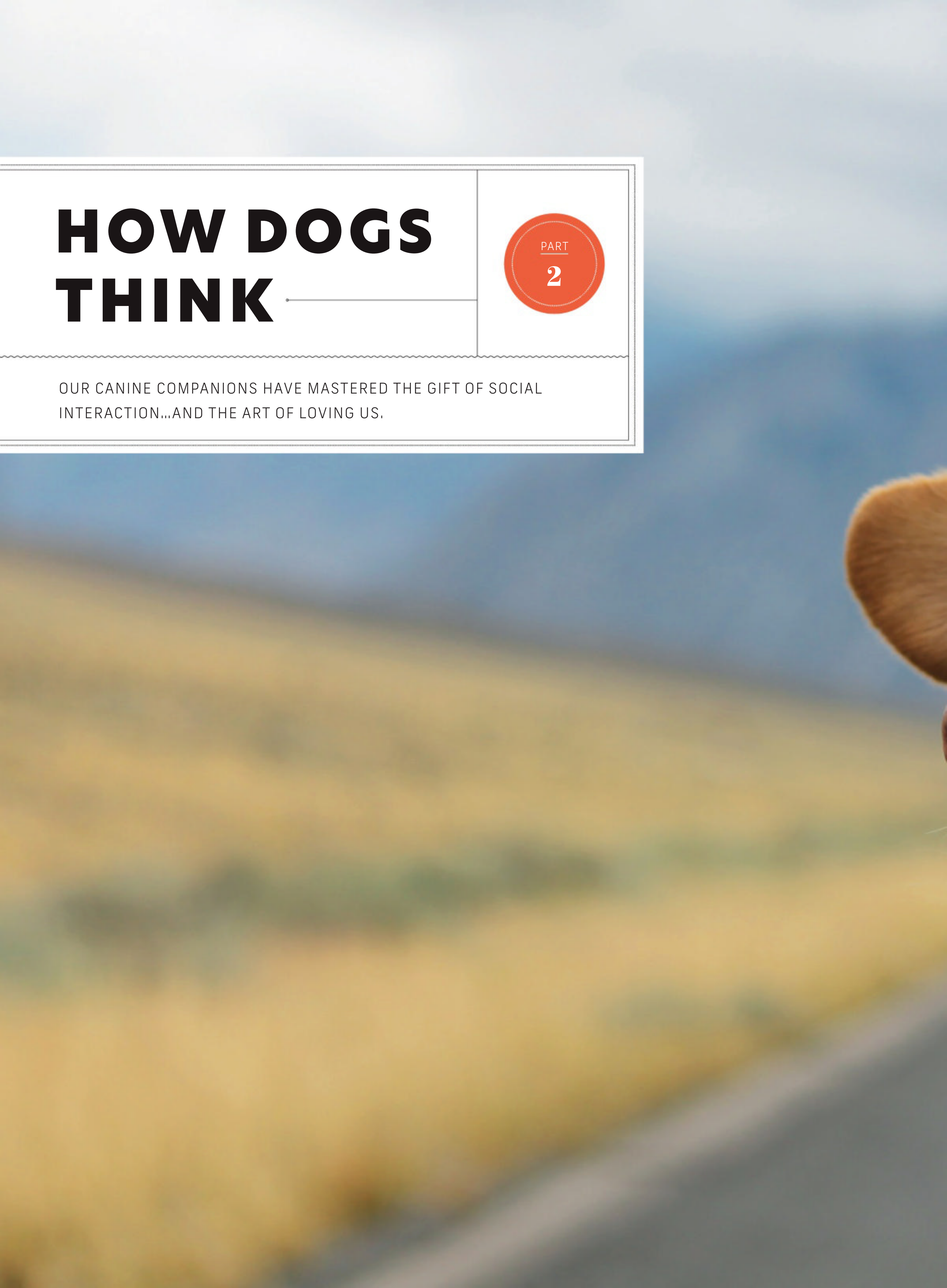
—Jillian Blume

HOW DOGS THINK

PART

2

OUR CANINE COMPANIONS HAVE MASTERED THE GIFT OF SOCIAL INTERACTION…AND THE ART OF LOVING US.



top talent

MANY ANIMALS ARE SMARTER THAN DOGS, BUT NONE DOES BETTER AT ACING THE SPECIAL SET OF SKILLS NEEDED FOR LIVING WITH US.

BY KAT ESCHNER

MANY PEOPLE swear that their four-legged canine companions are geniuses. But they may be blinded by love. Sure, dogs are smart—at least when working with humans. But pigs, for instance, are smarter than you think. That's the contention of Stephen Lea, PhD, professor emeritus at the U.K.'s University of Exeter, and former editor of the British journal *Animal Behaviour*. While the journal has published articles on the mental abilities of species as diverse as pheasants, mongooses and flies, a large number of the papers that came across his desk had to do with dog cognition.

"Through the process of working as an editor and seeing all this research, I definitely got a sense that we, as a collective, had gotten a bit overexcited about dog intelligence," he says.

DOGS CAN SOLVE MAZES AND HAVE AN IMPRESSIVE ABILITY TO USE OTHER ANIMALS' BEHAVIOR AS A CUE.

There are some obvious reasons for that. While dogs have been cognition research subjects since as far back as the 1800s—does the name Pavlov ring a bell?—Lea says that through most of the 20th century, researchers were mostly focused on primates and other species and stopped paying attention to the question of what dogs knew (and how). Then, in the 1990s, scientists began to look again at the species that is so present in human lives. However, in the rush of new research, he says, he wondered if dogs had been oversold as uniquely intelligent.

Where Dogs Stand

To try and figure out whether dogs were, in fact, animal geniuses, he and colleague Britta Osthaus, PhD, compared more than 300 existing cognition studies and published their finds in the journal *Learning & Behavior*. They compared dog studies of ability to comparable studies of three broad groups, all of which dogs could be said to fall into: carnivorans (fancy term for "carnivores"); social hunters that rely on one another to bring down prey; and domesticated animals.

What they found was that dogs didn't seem to stand out from other animals in any of the categories. There were carnivorans, social hunters and domesticated animals alike that could match or outcompete dogs in cognition tests. What was different about dogs was their ability to match animals *across* those three groups. Hyenas seem to follow the cues of others in their pack better, dolphins perform better in tests of self-consciousness, raccoons are better at physical puzzles. However, no other animal could perform as well in all categories.

"Every species has unique intelligence," says Lea. What he and Osthaus argue is that "their intelligence is what you would expect of [animals that are] recently descended from social hunters...that are carnivores and that have [also] been domesticated," he says. "There's no other animal that fits all three of those criteria."

The study takes an unusual approach to cognition studies, says Daphna Buchsbaum, PhD, the principal investigator at the University of Toronto's Canine Cognition Lab. "I think a lot of times, as humans, we naturally look at animal cognition through the lens of what makes them so similar to or different from us," she says. Here, Lea and Osthaus compare dog cognition to that of other animals, with some illuminating results. Even within their proposal that dogs aren't uniquely intelligent, she says, there may be "something interesting and unique" about dogs that enables them to sit in the middle of those three categories.

There are competing theories about why dogs are good at what they're good at—whether it's because of domestication, an evolutionary history of hunting in packs or for other reasons. Lea says that nobody knows exactly why dogs are the way they are, but this paper points to more questions about how they think as well as future research directions for other animals that have not been as widely studied as dogs. Studying other carnivores—particularly endangered species, such as the African painted dog or the dhole, which may go extinct before we can figure them out, Lea says—could offer a whole new window into pre-domestication dog cognition and provide some insight into those animals themselves.

IN TERMS OF SMARTS, THERE IS SIMPLY NO CASE FOR CANINE EXCEPTIONALISM.

As for dogs, Buchsbaum says, "The human environment is their natural environment, and that's not true of most of these other animals." Figuring out how dogs think could be very important—the North American dog population is large and growing, she says, and dogs play roles in our lives that range from aiding people with disabilities to sniffing out cancers.

So are dogs smarter than other animals? Well, maybe not. But they are arguably more present in our lives, says Buchsbaum. That's a reason to study their brains. Another reason, says Lea, is that they can take us far in studies of animal cognition because they are naturally comfortable around us. They make good test subjects. Still, he notes, this new paper also highlights other species that need more study.

"We'd know a lot more about dogs if we knew more about the intelligence of other species that are not dogs," he says.

DECODING THE CANINE MIND

IN RECENT YEARS, NEUROSCIENTISTS HAVE USED SOPHISTICATED TOOLS TO PEER INSIDE OUR DOGS' HEADS. HERE'S WHAT THEY LEARNED ABOUT THEIR INNER THOUGHTS.

BY GREGORY BERNS, PHD

EVEN THOUGH many people are convinced that they know what their dog is thinking, little is actually known about what is going on in dogs' heads. This may be surprising because the field of experimental psychology had its birth with Pavlov and his salivating dogs. But as canines gained traction as household pets, in many cases achieving the status of family members, their use as research subjects fell out of favor. In large part, this was a result of the Animal Welfare Act of 1966, which set standards for the treatment of animals in research and put an end to the practice of stealing pets for experimentation.

How strange it is that these creatures, whose nearest relatives are wolves, live with us and even share our beds, yet we know almost nothing about what they're thinking. In the past decade or so, however, the situation has begun to change, and we are in the midst of a renaissance of canine cognitive science. Research labs have sprung up around the world, and dogs participate, not as involuntary subjects but as partners in scientific discovery. This new research is beginning to shed light on what it's like to be a dog and the nature of the dog-human bond.

When scientists use animals in research, they often turn to species that are closely related to humans. "Close" is relative, since chimpanzees and bonobos diverged from hominids at least 5 million years ago. Monkeys diverged about 25 million years ago, and to find a common ancestor with the dog—indeed, with any carnivore—you have to go back 97 million years.

But this summary overlooks the very thing that makes dogs special: Their evolution has been altered to make them more socially compatible with us than any other animal. They were, in fact, the first animal to have been domesticated. The million-dollar questions are when and where this happened. We know that dogs existed at the time of the first human settlements in the eastern Mediterranean. In the area known as the Fertile Crescent, their remains have been found buried alongside humans, and these have been dated to 11,000 years ago. Cats, for comparison, did not appear until 8,000 years ago and probably didn't change into their modern form until 4,000 years later. It is fair to say that only dogs were present at the dawn of human civilization.

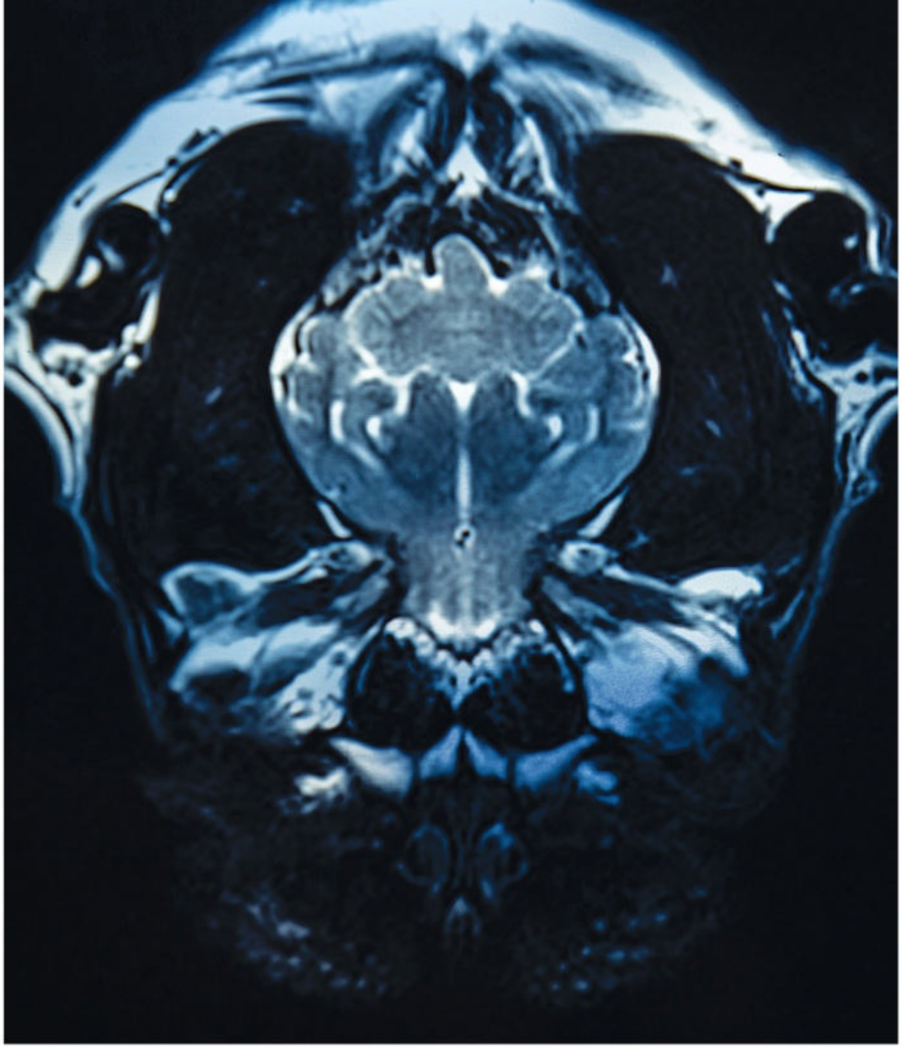
The world these early dogs and humans inhabited looked quite different from ours. Even though the last ice age was ending, the climate was still colder than it is now. This probably brought wolves (an ancestor of the dog) into more frequent contact with humans as the ice sheets retreated. One theory is that wolves and humans helped one another hunt, though it seems increasingly likely that the more social wolves began hanging around human settlements, to scavenge for leftovers. It is not hard to imagine a curious wolf, probably a juvenile, approaching the edge of a tribe. A human, maybe a child who wouldn't know any better, might leave some food on the perimeter. And a friendship is born. Eventually wolf-dogs, even if they didn't hunt, could act as sentries, alerting humans to intruders.

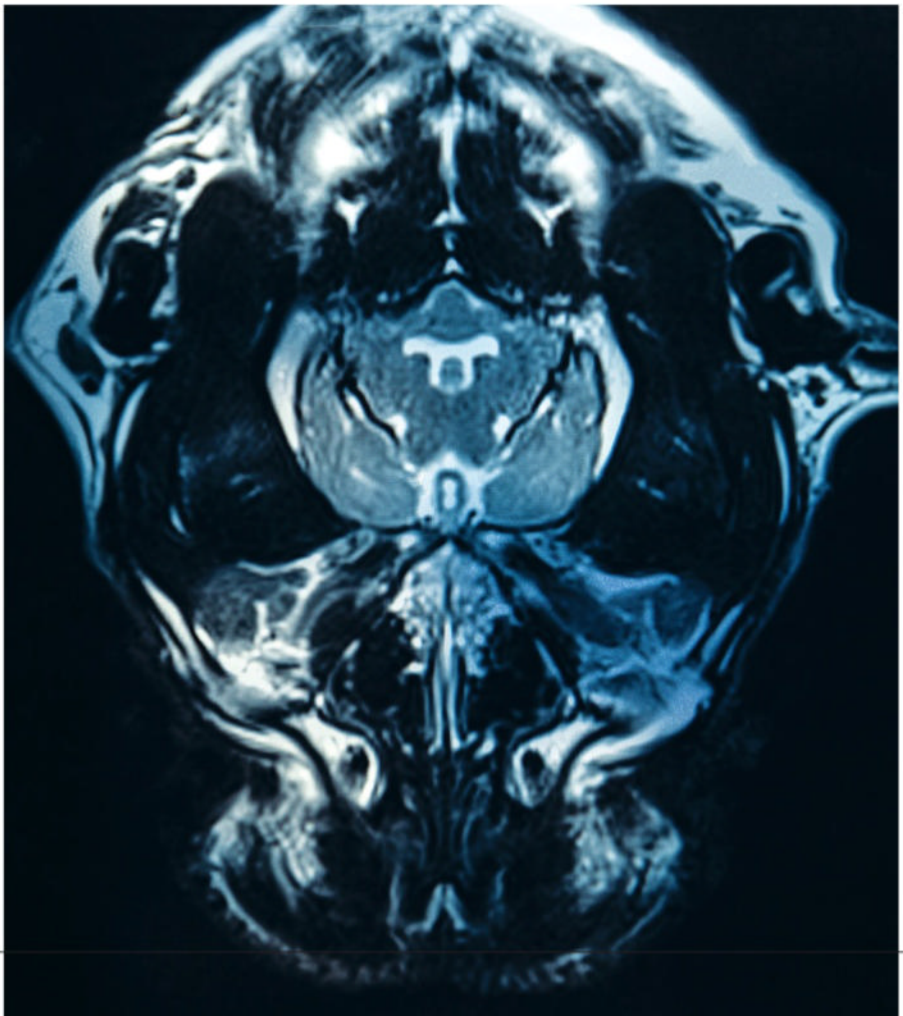
The evolution of cooperation is what allowed humans to dominate the planet, and at the dawn of civilization, we extended our ability to cooperate with each other to another species: dogs. (See "Finding Home," page 10, for how dogs evolved.) Although there is no fossil record of behavior, there is increasing genetic evidence for this sort of coevolution. In 2017, a team of researchers found a correlation between sociality in dogs with variants of several genes that had previously been identified in Williams, or Williams-Beuren, syndrome (WBS). In humans, WBS is a rare genetic disorder with a core feature of extreme friendliness. These results suggest that the key evolutionary event that turned wolves into dogs was an amplification of genes related to sociality. If that is true, dogs may hold the key to helping humans achieve what can often be a struggle: to be more social, more generous, more loving, more forgiving.

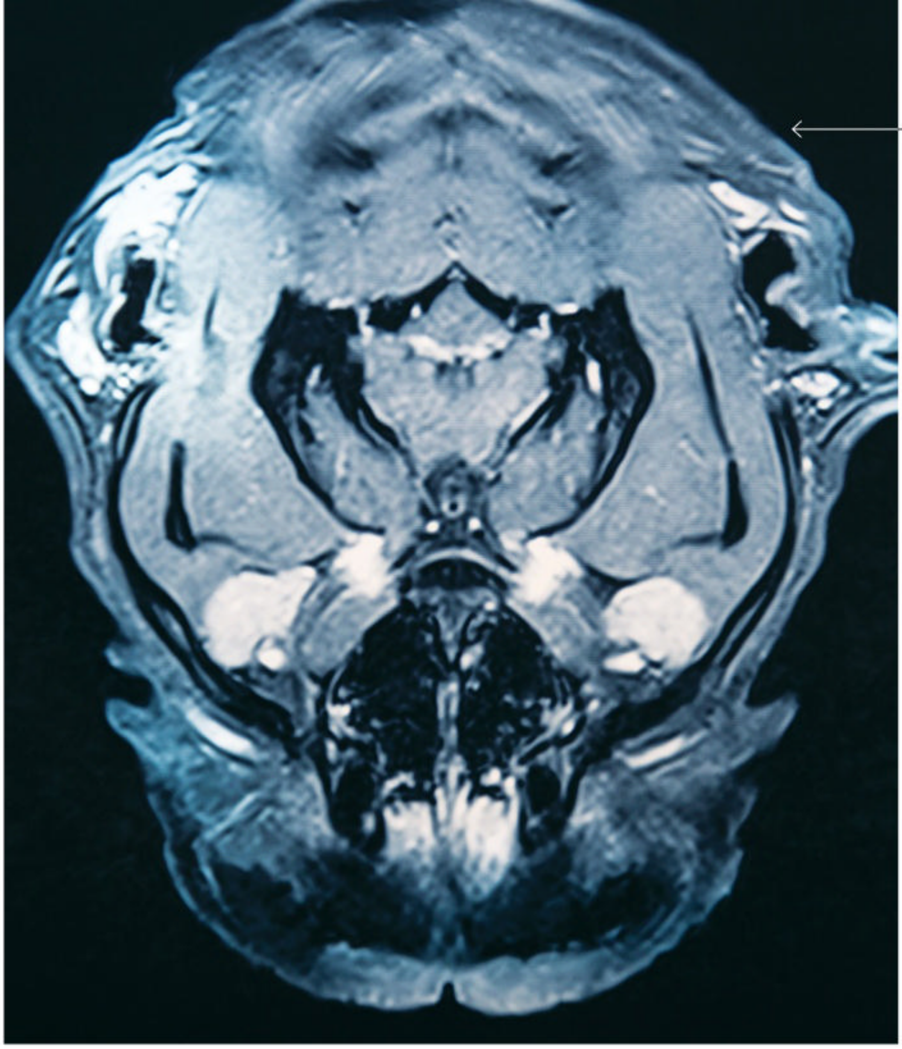
What It's Like to Be a Dog

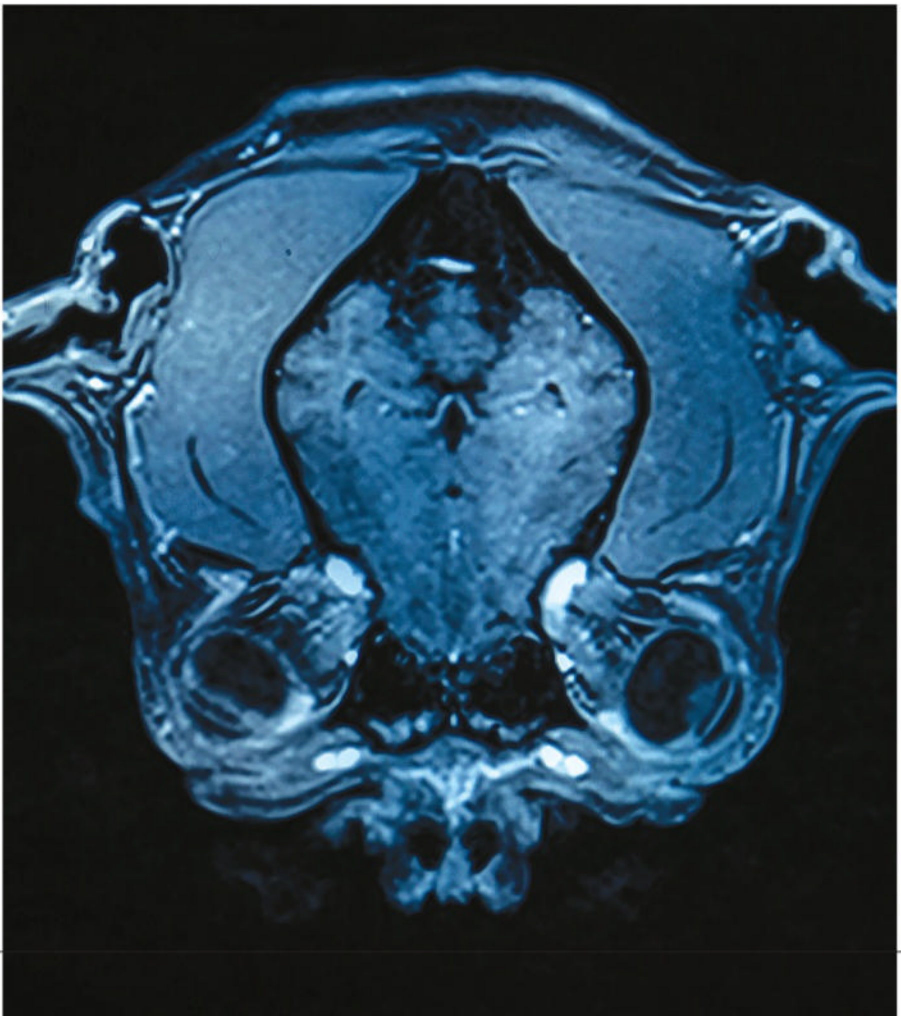
So what is going on in a dog's head? The traditional approach, pioneered by physiologist Ivan Pavlov, is to measure a dog's behavior under different circumstances and try to infer why they do what they do. But consider a common example: teaching a dog to fetch. Some dogs, like retrievers, may do this instinctively, but others do not. Is this because the nonperformers don't understand what is being asked of them? Or is it that they understand but would rather do something else? It is all too tempting to project a human explanation onto the dog, to anthropomorphize. The fetch example also highlights an important point: Dogs, like people, are individuals. We must be careful in generalizing about dog findings, because there is no such thing as a generic dog. Just like there isn't a generic human.

Because of the limits of interpreting behavior, my colleagues and I turned to the use of brain imaging to figure out what dogs are really thinking. When we began 10 years ago, our approach was different from that of most animal research. Instead of treating the dogs as research subjects, we treated them as if they were voluntary participants, affording them the same basic rights as human volunteers. We did not use sedation or restraints. Instead, we developed a training program that taught the dogs to walk into a









DOGS MAY HELP HUMANS ACHIEVE WHAT MANY FIND HARD: LOVE, GENEROSITY, FORGIVENESS AND FRIENDSHIP.

functional magnetic resonance imaging (fMRI) scanner, place their heads in custom-designed chin rests, and lie comfortably while it scanned their brains. Since then, we've trained 100-plus dogs for fMRI. Many have been participating for their entire lives and have gotten so used to the scanner that it is hard to get them to leave!

Before getting into how a dog's brain works, it should be understood, even if obvious, that dogs do not have the same amount of neural infrastructure that humans do. As a rule, larger animals have larger brains. This relationship between brain and body size is often described as the encephalization quotient (EQ), such that an EQ=1 means an animal has an average brain size for its body weight. Humans have an exceptionally large EQ of about seven, while dogs measure a bit better than your average mammal, with an EQ of 1.2. However, we can see from an MRI of a dog brain that even though it is smaller than a human brain, all the same basic structures are present. This is true for large regions, like the cerebral cortex (the center of cognition) and the cerebellum as well as for smaller structures, like the brain stem, hippocampus, amygdala and basal ganglia, which have important roles in movement, memory and emotion.

Dogs also have large olfactory systems—they comprise about 2% of the total brain weight (compared to 0.03% percent in humans). Where dogs fall short is in the cortex. Apart from being smaller, there are fewer folds, which means less surface area and fewer neurons. And the frontal lobe, which in humans occupies the front third of the brain, is relegated to a paltry 10% in dogs.

The commonality of brain structures is true across all mammals. While there may be differences at a microscopic level, we all carry around the same basic hardware. Scientists and philosophers continue to debate whether a dog's experience is the same as a human's, but the commonality of brain structure suggests a certain commonality in function as well. Dogs have a hippocampus because they have to remember things too. They have an amygdala because they get aroused and excited and scared, just like we do. They may even suffer similar mental problems (more on that later).

We have discovered many things about dogs' perceptual experience of the world, but those that are most interesting are in the domain of social cognition. The first question many people ask is, "Does my dog love me?" Without getting into the nuances of love, the question gets to the heart of the dog-human relationship—namely, what are a dog's motives? Is it all about food, or can dogs experience positive emotions for purely social reasons? To answer the question, we used fMRI to measure activity in a structure at the heart of the brain's reward system: the caudate nucleus.

Before scanning, we trained the dogs on a simple association between toys and rewards. Each toy was held in front of the dog for 10 seconds and then followed by either a treat or by their owner popping into view and praising them with, "Good dog!" The toy set up a state of expectation, which we could measure in the caudate. We found that 13 of 15 dogs had equal or greater activation for praise than for food. Is that love? We don't know, but it does show that most dogs have brain systems highly tuned to social rewards, and some even respond more to their owner's praise than to food itself.

How does this social bond form? Humans, like most primates, are born ready to bond with their parents and other members of their social group. Faces carry a wealth of social information, and in the 1990s, neuroscientists discovered that primates have an area of their visual systems dedicated to processing faces, called the fusiform face area. To see if dogs have equivalent areas, we showed pictures and videos to dogs while they were in the MRI scanner. We showed faces (dog and human), objects, scenes, scrambled images. And just as in humans, we found an area of the dog visual system that is strongly and specifically activated by faces. We called it the "dog face area." Like the praise experiment, this demonstrates that dogs have more in common with us than we realized and that they have the basic tools to process human faces.

While we humans identify people by their appearance, dogs may rely on their sense of smell. In an early fMRI study, we presented dogs in the scanner with five scents: their owner's, an unfamiliar person, another dog in the house, an unfamiliar dog and their own scent. Human scents were obtained from underarm wipings and dog scents from the area that dogs like to smell—their butts. Although we expected to find the strongest response to the smell of other dogs, in fact we found that the scent of the owner elicited the greatest activation in the reward system of the dog's brain. This means that dogs not only can identify us by smell, they seem to like the smell of their human best.

A SPECIAL AREA OF THE DOG'S BRAIN IS DEVOTED TO IDENTIFYING FACES OF HUMANS AND OTHER DOGS, BUT WHEN IT COMES TO RECOGNITION, PUPS RELY MORE ON SMELL.

Talking to Dogs

What about dogs' ability to understand human speech? Here, we have to be careful in what we mean by "understand." Dogs seem to understand basic commands like "sit" and, to varying degrees, "come," but that does not mean that they understand words the way humans do. We use words as symbolic placeholders. We are also very noun-centric. There are roughly 10 times as many nouns as verbs, in part because we label everything. A dog, however, may find actions more salient than names. Humans know that the word "ball" represents a whole class of objects, and its precise meaning derives from how it is used in a sentence. When a dog hears the word "ball," do they conjure up an image in their mind's eye like a human would? Maybe "ball" to a dog means the act of retrieving something, or maybe dogs pick up salient information by the tone of our voices when we say the word.

As a first step toward answering these questions, we taught some of the MRI dogs the names of two new toys. To do this, the owner would point to a stuffed animal and say its name, for example, "monkey." When the dog moved toward the toy, it would be given a treat. Gradually, we removed the pointing. When the dog learned the name of one toy, we then introduced a second. After learning that, the dogs had to make the correct choice by name when both were present. Before they were deemed ready to scan, a dog had to demonstrate its knowledge by being 80% accurate in picking the correct toy on command, much like the famous dog Chaser, who was reported to know the names of 1,000 toys. (See

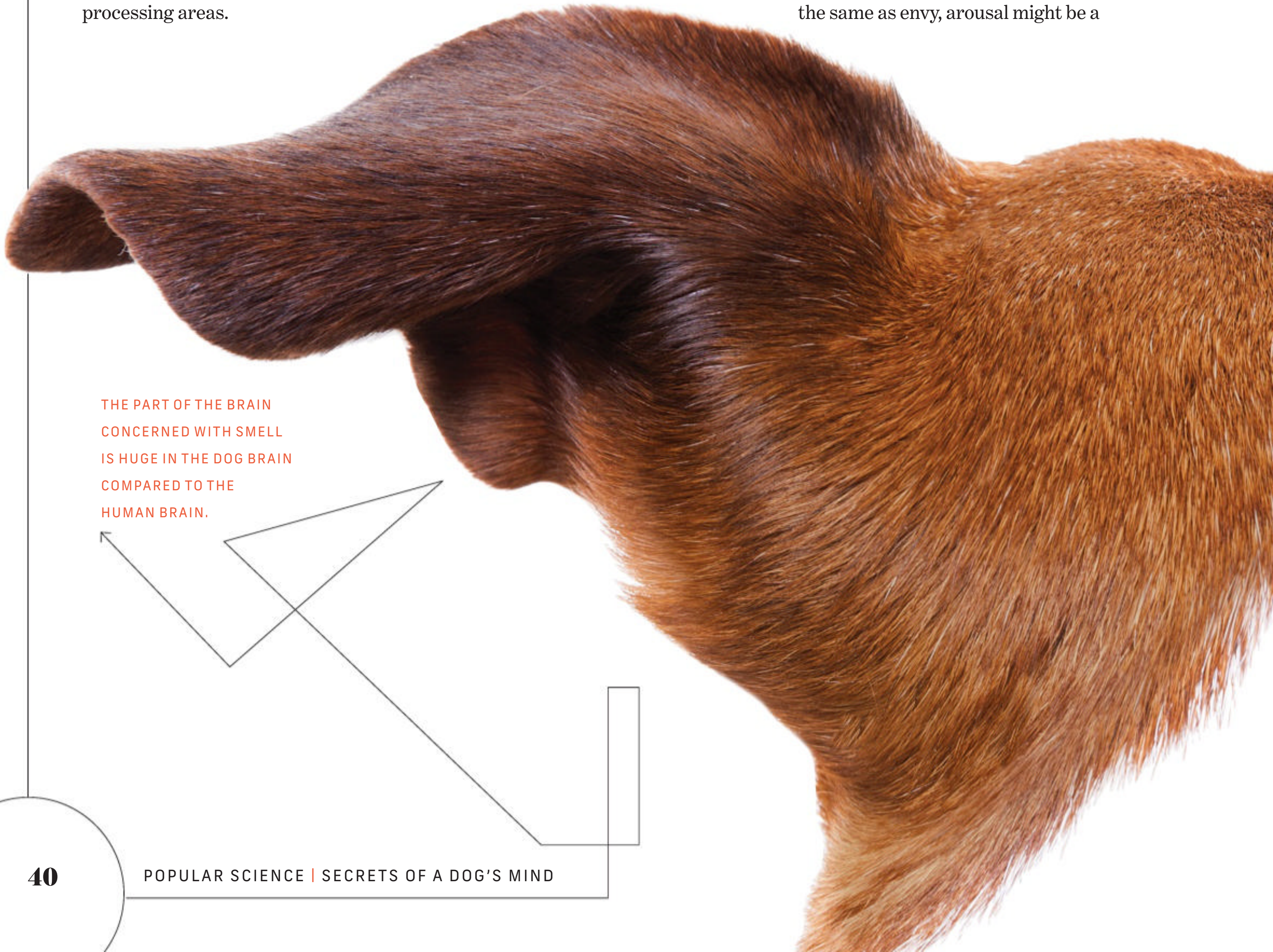
"When I Met the World's Smartest Dog," a profile of Chaser, on page 82.)

With the dog in the scanner, the owners spoke the names of the different toys. As a control condition, they also spoke gibberish words that the dogs hadn't heard before. When this type of experiment is done in humans, real words activate language areas more than fake words, presumably because humans immediately recognize gibberish and stop trying to extract meaning from it. But in the dogs, we found the opposite. The gibberish words caused more activation in auditory areas than the real words. These areas extended beyond what is considered primary auditory cortex, and so we think they represent rudimentary language processing areas.

This tells us two important things. First, dogs can discriminate between words they have heard before and those they haven't. Second, their reaction to novel words is different from humans'. Instead of immediately recognizing that they have no meaning, dogs pay close attention to novel words, perhaps to figure out what their human is trying to communicate. This response may derive from their hypersociality and desire to please. (However, you can be sure that a dog will learn to ignore you if you constantly speak gibberish.)

Mapping Emotion

What about complex emotions, like guilt? While many people believe their dog knows when they've done something wrong, researchers continue to debate whether dogs have the capacity to experience emotions like shame or guilt. Unfortunately, we can't use fMRI to look for a neural signature of guilt in a dog, in large part because we haven't found one in humans. (This may seem surprising, but it has been devilishly hard to find reliable neural markers of human emotional states in general.) However, we've found evidence for something like envy in the dog's brain. In this experiment, the dog had to watch their owner feed a realistic statue of a dog. As a control condition, the owner placed food in a bucket. We found evidence for amygdala activation, which is a neural marker for arousal, when the fake dog was fed. Although not quite the same as envy, arousal might be a



THE PART OF THE BRAIN CONCERNED WITH SMELL IS HUGE IN THE DOG BRAIN COMPARED TO THE HUMAN BRAIN.

response to envy. This wasn't universal, however. Only the dogs who displayed aggressive traits toward other dogs had this amygdala response. Again, this highlights the individuality of every dog.

A complementary approach toward decoding emotional states uses machine learning to mine brain data obtained while a person (or dog) watches videos with different types of emotional content. Building on early results of decoding content of visual images from the brain, this new approach suggests a map of emotions in the human visual system, including states like anxiety, awe, fear, disgust, joy and adoration. Machine learning techniques require a lot more data than conventional fMRI experiments provide—typically hours in the scanner for each subject. This would seem impossible for a dog, but with each visit to the scanner, we have found that the MRI dogs get more and more comfortable with the environment. We have several dogs who are content to lie there, watching whatever content we create for them. Preliminary results suggest that it's possible to decode brain states in some dogs. In the language study, for example, we were able to decode which word was spoken from about half of the dogs' brains. As we extend this approach to more complex stimuli, we may soon be able to decode emotional states and learn what makes them so hypersocial and lovable.

If dogs have evolved to be man's best friend, is it possible that they also suffer from some of the same mental disorders as people do? Growing evidence suggests that the answer is yes—and this is all the more reason to take a closer look at what is going on in dogs' heads.

Human mental illness is diagnosed largely by symptoms. According to the fifth edition of the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), depression is characterized by depressed mood, diminished pleasure, slowed thinking, fatigue, feelings of worthlessness or guilt and thoughts of death. The only objectively measurable symptom is weight change. Similarly, generalized anxiety disorder is associated with excessive anxiety and worry, restlessness, fatigue, decreased

!

DOGS MAY SUFFER FROM SOME OF THE SAME MENTAL DISORDERS PEOPLE DO.

concentration, irritability, muscle aches and sleep problems.

Dogs, of course, cannot speak, so they can't report whether they're feeling sad or anxious. Although neuroimaging may soon change things, we currently have to rely on dogs' behavior to infer what they are feeling. For example, when dogs are scared, they behave in characteristic ways that include trembling, hiding in closets or under furniture, chewing or scratching doors to escape, pacing, barking, whining, and defecating or urinating in the house. When these occur in the context of being left alone, they are often labeled as separation anxiety.

Aggression is another frequently misunderstood manifestation of emotional states in dogs. What humans label as aggression may be a normal part of a dog's behavioral repertoire, which includes barking, growling and biting. Any dog can bite, and most will do so if provoked sufficiently. However, when they bite, dogs can cause serious injury, especially to children.

Interestingly, dogs with behavioral problems often improve when they are treated with human medications for depression and anxiety. Serotonin and norepinephrine reuptake inhibitors, like fluoxetine (Prozac), are some of the most commonly prescribed drugs in veterinary behavioral medicine. Others include benzodiazepines, tricyclic antidepressants, beta-blockers and even lithium. Indeed, the psychopharmacopeia for dogs is nearly the same as for humans.

The fact that these meds work in dogs speaks to common biological mechanisms of mood regulation. And while dogs aren't susceptible to placebo effects, their owners might be, by expecting improved behavior.

BRAIN SCANS CAN TELL US WHEN A PUPPY MAY BE TOO EASILY AROUSED TO BE A GOOD CANDIDATE FOR SERVICE DOG SCHOOL.

Notwithstanding their emotional quirks, dogs have been able to be used in a variety of capacities to help people with disabilities. Service dogs are trained for specific tasks that a person cannot do by themselves, which might include picking up items, opening doors and alerting them to sounds. A psychiatric service dog might be trained to detect the onset of psychiatric episodes or to turn on lights for someone with post-traumatic stress disorder. In contrast, emotional support dogs are not trained for specific tasks but used for companionship, to alleviate loneliness and to aid in the treatment of depression and anxiety.

While service dogs are afforded certain protections under the Americans with Disabilities Act, emotional support animals are not (although they may be covered by other laws, like the Fair Housing Act and Air Carrier Access Act). Because service dogs often require extensive training, the cost (up to $50,000) may be prohibitive for many people. Most dogs are not cut out for this kind of work, so there is a need to identify those that are and not waste resources training those who will not be good service dogs. Brain imaging may play a role here. In a study of 50 dogs-in-training, we were able to predict with 91% accuracy whether a dog would or would not graduate service dog training. In particular, we found that amygdala activation was negatively correlated with success, suggesting that dogs that are prone to arousal—either because they are anxious or simply want to play—are not good candidates for service dogs.

It is worth keeping in mind, however, that dogs are not simply treatments to be prescribed for various human conditions. Like people, dogs have a wide variety of skills and personalities. (See "This Dog's Got Personality," page 78.) And while there are some differences between breeds for any particular personality trait, there seems to be just as much variability within a breed.

The key to a strong dog-human bond is in the match between dog and human, but this may be as hard to predict as a match between two people. Future research, using both brain imaging and other physiological measures, may soon shed light on the canine side of the equation.

This article originally appeared in Cerebrum *magazine, published by the Dana Foundation. Gregory Berns, PhD, is the Distinguished Professor of Neuroeconomics at Emory and co-founder of Dog Star Technologies—a company using neuroscience to enhance the dog-human partnership. He has put more than 100 dogs through a brain scanner in order to measure their inner lives.*

MRI SCANS SHOW THAT DOG BRAINS AND HUMAN BRAINS CONTAIN THE SAME BASIC STRUCTURES. BOTH SPECIES RESPOND TO THE SAME PSYCH MEDS.

canine enrichment for the real world

THE BIGGEST CONSTRAINT TO ENHANCING YOUR DOG'S LIFE IS YOUR IMAGINATION!

BY JILLIAN BLUME

A SHELTER dog named Sarge set Allie Bender on the path to becoming an animal behaviorist. At the time, she was working in a shelter, and Sarge was struggling to adjust to the noisy, chaotic shelter environment. Sarge's behavior deteriorated. He reacted when anyone tried to place him on a leash and barked, growled or lunged at other people, dogs and activity beyond the confines of his kennel.

"I did as much as I knew how to, at the time," says Bender. She set up a program that included adding toys and food puzzles. "I tried training him, but I didn't have the knowledge to help a dog like him." Despite Bender's attempts, Sarge eventually bit a child who was trying to greet him—and that was the end of the dog's life.

Though it was too late for Sarge, Bender realized that what he had needed was not more-rigid training but a program of behavior modification and focused enrichment that helped him transcend the roots of his fear.

Techniques for enrichment were pioneered in Swiss zoos in the 1950s, when Heini Hediger, director of the Basel Zoo, took five young East African elephants on regular walks through the city. When he moved to the Zurich Zoo, he created the Africa House, where different animal species lived in the same enclosure, to form the same symbiosis found in nature and create a more natural environment.

In the 1970s, Hal Markowitz, PhD, an animal behaviorist at San Francisco State University, expanded on the concept of enrichment by teaching captive animals to obtain their own food and to make choices in the environment. He defined enrichment as "more like nature."

Bender has paid attention to these lessons from Hediger and Markowitz. Now a certified dog behavior consultant, a trainer and the

IF YOUR DOG LOVES SPINNING AND TWISTING, PLAYING FRISBEE MAY BE A BETTER ACTIVITY THAN WALKING TO TOWN.

founder of Pet Harmony in Glen Ellyn, Illinois, she and colleague Emily Stone, another animal behaviorist, wrote the book, *Canine Enrichment for the Real World*, in part to challenge the many counterproductive techniques still sometimes used by dog trainers today.

Canine enrichment, she says, does not mean throwing a bunch of toys at your dogs, as she once did with Sarge, or taking them to the park. Instead, enrichment is learning about an individual dog's natural behaviors and needs, then structuring an environment that fits. Dog parents who are interested in enrichment should follow these steps.

Foster a Sense of Agency

To truly enrich your dogs, you must know them as individuals and allow them to have a sense of agency over their own lives.

"Agency is the ability to have control and make a decision that affects positive outcomes in your life," says Bender. As an example, she uses the food puzzle, which requires a dog to figure out how to get the food out. Most people assume that this activity would qualify as enrichment for a dog, right? Not always, Bender notes. "If you give your dog a food puzzle and the dog isn't interested, then the food puzzle doesn't count as enrichment. The dog is choosing not to interact with it." That's the agency part. But that doesn't mean your dog's decision is a final one. You can try something else—or you can teach your dog how the puzzle works.

Fight Learned Helplessness

Learned helplessness is something that many dogs experience at one time or another. It is a sense of powerlessness, usually due to an inability to escape unpleasant or painful situations. Once the dog realizes that nothing it does will make any difference, it will shut down behaviorally and even physically. This may come across like the dog is being “good,” but it’s actually an expression of defeat.

For example, Bender once had a client with two American bulldogs. Usually, this breed is playful and goofy. But when Bender met Mork and Mindy, she was struck by how serious the dogs were. They were aloof and refused to engage with her. Though they were trained well in following commands, the dogs had started exhibiting compulsive behaviors that were causing injury, such as licking the sides of their crates until their mouths were bloody. The owner took the dogs to different veterinarians and implemented multiple food tests for potential allergies, but nothing she did had an effect.

Bender discovered that the owner had followed the now debunked domination theory of training: She was the alpha and had control over her dogs at all times. The dogs slept in their crates at night and when the owner was at work. On walks, the dogs wore a prong collar, and if they tried to sniff and explore or to approach people on the street, they were immediately “corrected.” In the evening, the dogs obediently rested on their assigned mats until bedtime, when they went back into their crates to sleep.

Mork and Mindy had learned not to explore or engage with their environment. They had been told, for their entire lives, what to do and when to do it, so they had never used their brains to solve any problems.

The owner actually loved her dogs and thought that teaching them to be obedient meant she was a responsible pet owner. Bender explained the concepts of agency and learned helplessness, and she created an enrichment plan, to teach the dogs how to use their noses, explore their environment and solve problems. The dogs’ compulsive behavior disappeared, and their outsized, silly personalities began to emerge. The woman reported that watching her dogs flourish and their minds awaken was one of the most joyful experiences of her life.

Be Descriptive Instead of Prescriptive

In descriptive training, you observe the effects of an activity or toy and actually see that it has an impact on behavior in a positive way. In prescriptive training, you give your dog the activity and toy and assume they’re enriched without seeing any effects that substantiate that claim.

Bender often has clients with adolescent dogs whose owners

mental stimulation through training

To enrich dogs through training, behaviorist Allie Bender works with the methods below. To engage your dog through these mental stimulation techniques, find what reward motivates him to do some work. It can be treats or a ball, as long as the dog is willing to work for it. Teach your dog the skills and reward him when they get it right.

SHAPING

This technique gradually teaches a dog a new skill or behavior by rewarding her for every step toward the end goal. As the dog learns each step, you move on to harder ones. This breaks up complicated actions into smaller parts that are easier to learn. For example, to teach a dog to go into the crate, start by rewarding when the dog looks at it, then when she takes a step toward it, steps closer, puts a paw inside, etc., until the dog walks inside.

LURING

This uses a lure, typically food, to lead the dog into the behavior. To teach a dog to sit, let him sniff a treat, then move the treat close to his face, up and over his head. The dog’s nose will follow it, which automatically causes the body to sit, and you give the treat. To teach the dog to lie down, let him smell the treat, then slowly move the treat down toward the ground. The dog’s head will follow until he’s lying on the ground...and gets the reward.

CAPTURING

Capturing uses a behavior the dog does on her own. When the dog naturally sits, you say “Sit!” and reward with a treat. You can also use this for cute or unusual things a dog does. If a dog likes to spin around in excitement, you can call that behavior “Spin” and reward. If a dog reaches out to touch you, turn that into “High-five!” with shaping.

Not Recommended

MODELING

This is a popular technique that Bender finds counterproductive. Here, the dog is moved into a position—for example, pressing down on her rear end—to get her to sit. This may turn your dog's focus from the activity into a desire to escape.

THIS RUSSELL TERRIER LOVES NOTHING MORE THAN RUNNING HIS FAVORITE AGILITY COURSE FOR A REWARD.

complain that they're "still bouncing off the walls," despite a very long walk every day. "I have to tell them, that means a three-mile walk isn't physical exercise for their dog." To find out what *is* exercise for that specific dog, Bender may suggest trying various dog sports, like agility training or dock jumping.

Enable Enactment of Foraging Behaviors

Enrichment encompasses instinctual behavior, such as foraging. While wolves are greater risk-takers than dogs, relying predominantly on hunting, feral dogs generally rely on scavenging from human food sources. Dogs will usually choose to work for their food instead of being handed it in a silver bowl, Bender explains.

For example, she had clients who complained that their dog refused to eat from a dish. Instead, the dog would flip it over, sending kibble flying across the kitchen, and then he would happily forage for his food under the refrigerator and wherever else it had landed. She suggests that some owners may want to get rid of the bowl and feed their dog by using a food puzzle.

Create Opportunities to Use the Sense of Smell

Because the part of a dog's brain allotted to the sense of smell is about 40 times greater than ours, exercising their nose gives dogs a real workout. Scent work can be anything from allowing a dog to spend as much time as they want sniffing the environment on their daily walks to using structured scent games. These can include food puzzles, snuffle mats, and scent games in which the dog has to find hidden treats or a person in hide-and-seek.

FACED WITH A CHALLENGE, DOGS CAN DECIDE TO PUSH THROUGH.

Add Other Sensory Stimulation

Dogs are also enriched by things that stimulate sight, sound, taste and touch. They are extremely sensitive to touch, so use hard and soft toys, ball pits, blankets with different textures, walks on different surfaces. For sight, take new routes on walks and trips to new environments, like the beach and hiking trails. Dogs have a more powerful sense of hearing than humans do, so be careful with loud sounds. A study from the Institute of Biodiversity at Scotland's University of Glasgow found that dogs find some music soothing and prefer classical, reggae and soft rock. Taste is the easiest; just switch up their treats.

> "IF WE TAKE A DOG TO A DOG PARK AND IT JUST SITS THERE COWERING, THAT'S NOT ENRICHMENT."
>
> *ALLIE BENDER, PET HARMONY FOUNDER*

When Offering Activity, Refer to Your Dog's Breed

Humans have been selectively breeding dogs to perform specific tasks, and so each breed has unique genetic tendencies. Herding dogs, like the border collie will herd everything from children (scary!) to cats (futile). Scent hounds, like beagles and basset hounds, are more vocal; dachshunds, originally bred to hunt badgers, like to dig. Use breed tendencies when planning enrichment activities. For herding dogs, the dog sport Treibball is perfect because it uses balls of different colors and sizes that must be "herded" into a soccer goal. For scent hounds, use hidden treats or play games of hide-and-seek, and for diggers, use snuffle mats or try some treats hidden underneath a blanket.

Promote the Right Kind of Social Interaction

A common misconception is that dogs need to socialize with other dogs. Not necessarily, Bender says; it depends on the dog. Let dogs that love people interact with friends and strangers on walks, at the park or at gatherings. 🐾

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OUR PET DOGS HAVE EVOLVED WITH A SPECIAL VOCAL LANGUAGE, TO HELP THEM COMMUNICATE WITH US.

what barks mean

YOUR DOG'S UTTERANCES ARE REPLETE WITH NUANCE. HERE'S HOW TO READ BETWEEN THE SOUNDS.

BY JILLIAN BLUME

TO THE untrained ear, all barking may sound the same. The trick to learning to speak fluent dog is fine-tuning your ability to hear subtleties. Dogs communicate with the world around them and with humans using a variety of sounds—including barking, baying, howling, whining, growling, yelping, groaning and sighing. While some sounds are easy to interpret, like the yelp when you accidently step on your dog's tail, the bark is the most difficult to decipher because its meaning and sound quality changes: A dog's bark when a doorbell rings has a sound that's different from the bark of a dog excited to go for a walk. The meaning can be found in the volume, tone, pitch, duration and situation. You must also factor in your knowledge of the individual dog and breed. For example, the bark of a German shepherd may naturally sound more alarming than that of a toy dog, but the shepherd may actually just be saying, "Hey, what's up?"

Kayla Fratt, certified dog behavior consultant at Journey Dog Training, uses the ABCs of behavior analysis to determine the meaning of an individual dog's bark. To translate, look at what happened right before the dog barked (the **a**ntecedent); what his demeanor and body language indicate (the **b**ehavior); and then what happened right after the dog barked (the **c**onsequence). Researchers like the late Sophia Lin, DVM, a renowned veterinarian and animal behaviorist, have studied the variations in a dog's bark by listening closely as well as observing the situation and environment in order to translate its meaning.

HEY!

The Isolation Bark

The isolation bark is the canine equivalent of yelling “Hey!” to get someone’s attention. Most often heard as one emphatic bark at a time, it’s higher-pitched and has more tonal and frequency changes. It often occurs when a dog is kept away from its owner, whether spending a time-out in the crate or corralled behind a baby gate in the kitchen while the family eats dinner (beggar-free). You may also hear the isolation bark when a dog’s toy is stuck under the couch or if it keeps dropping the ball at your feet but you’re just not catching on. While the isolation bark is heard mostly as a single exclamation, some dogs learn to repeat it until their human reappears or pays attention to them.

OMG!

The Disturbance Bark

This bark is activated when a dog hears someone in the hallway or walking toward your front door (or slinking around the side of your home, with questionable intentions). It starts as a low-pitched, harsh bark, with little variation in pitch or volume. If that first bark doesn’t scare the stranger off or bring you running, the dog ups the frequency, producing barks that get closer together as the disturbance approaches. When the stranger rings the doorbell, knocks on the door or trips over the garden hose in the yard, the barks are blurted at full volume, close together, until they fuse into what Yin called the superbark. It’s a dog’s loudest, can’t be ignored, intruder alarm.

RABBIT!

The Bay

Beagles, Plott hounds and other breeds bay because they were selectively bred to hunt small game by surrounding it (also called keeping the animal “at bay”) and alerting the human hunters with their very loud baying sound. The deep, long call of the bay dog is a cross between a bark and a howl. The dog throws its head back; opens its throat; and lets loose an enthusiastic, resounding call. The bay is capable of carrying over long distances so that hunters can hear it when the dogs are out of sight. While beagles are still used for hunting small game, most of them bay just because they like to, whether to let you know the mail carrier has arrived or to start a party with their neighboring dog friends.

STAY AWAY!

The Growl

Growling is a low-pitched, continuous rumble that is most often a warning—but it isn’t always. It’s especially important to know how to read a dog’s body language, to correctly translate the growl. Some dogs growl when they’re playing with their human, as in the tug-of-war growl, or when they want you to play, as in the “Are you blind? I’ve dropped this stick at your feet three times” growl. Two dogs playing will often emit “happy” growls, accompanied by the play bow and a relaxed body language, with a raised, wagging tail. However, a low-pitched growl accompanied by stillness, a lowered head and a lifted lip means “Back off.” Ignore (or fail to interpret) that warning at your own risk!

TO UNDERSTAND YOUR DOG’S BARK, PAY ATTENTION TO THE THREE DIMENSIONS OF CANINE VOCAL LANGUAGE: THE PITCH; THE DURATION; AND THE REPETITION, OR FREQUENCY, OF THE SOUND. A LOW-PITCHED BARK IS AGGRESSIVE, WHILE A HIGH-PITCHED BARK INDICATES A WILLINGNESS TO PLAY.

PAY ATTENTION!

The Whine

A dog's whine is akin to a child or teenager's "Moooommmm!" or "Daaaad!" It's a high-pitched sound, made with the mouth closed. It usually means the dog wants something. Maybe a toy is stuck under the couch or it's close to dinnertime or the dog needs to go outside—or just wants attention. The whining should stop, once you figure out and fix the problem (unless your dog is whining while you're eating a meal, but that's another issue). Sometimes a dog's whine has a specific message. Accompanied by panting, pacing, trembling and licking the lips, whining can indicate fear, frustration or anxiety. And if there is whining every time your dog tries to go up the stairs or jump on the bed, it may be injured or experiencing joint pain.

I AM WOLF!

The Howl

A long time ago (in a faraway land), dogs descended from wolves; a dog howls to get in touch with his inner ancestral wolf. While a howling dog probably isn't letting the rest of the pack know where it is, dogs are trying to communicate when they throw back their heads and let loose the long, sad, crying sound of a howl. Some breeds tend to howl more than others, including breeds that resemble wolves—like the Siberian husky, Alaskan malamute, Shetland sheepdog and American Eskimo dog—and breeds that...don't, like the bloodhound and basset hound. Dogs howl in response to high-pitched sounds, like an emergency siren, or in response to another dog's howling (that's the inner wolf). Behaviorists believe that dogs also howl in order to alert their humans to danger, scare off intruders, express anxiety or pain, or celebrate finding prey or a new discovery (squirrel!)—or simply because they want attention.

AHH!

The Sigh

Dogs will sigh deeply when they are content. They may be settling down for a nap; curling up next to you on the couch; or plopped on their side, ready for some bedtime spooning. That deep inhalation and exhalation of breath is the canines' way of saying "Ahh, paradise." They are relaxed and satisfied. Less common is the dog that sighs when disheartened. You've been staring at your computer all day, not even noticing when your dog drops a ball at your feet. Your pup finally plops down in its bed and sighs loudly. Yes, the dog is content to lie in a cushy bed, but this also lets you know that your pet is deeply disappointed in you. Constant sighing coupled with groaning may signal that your dog is in some pain or discomfort and needs to see the veterinarian.

OUCH!

The Groan

A dog that groans is either very content or in physical pain. Some dogs will groan as a way to communicate pleasure when you pet them or when they settle down for a nap in a comfy bed after a long hike. However, groaning can also indicate discomfort or pain, especially in older dogs or those with joint conditions. In that case, the groan is the equivalent of "Oh, my aching back/knees/hips!" Besides arthritis, a dog with a condition called ascites, which is a buildup of fluid in the abdomen, may groan when lying down and struggle to find a comfortable position.

PART
3

THE CANINE CANVAS

SIGHTS, SOUNDS, SCENTS AND ALTERED STATES.

BITS AND BITES

EIGHT FASCINATING REVELATIONS FROM THE FRONTIERS OF CANINE SCIENCE

THE EMERGENCE of animal cognition labs in recent years has led to an abundance of new insights into the dog's mind and the shared human-canine world. Here are some of the most fascinating new finds.

1

THE SOCIAL SMARTS OF WORKING DOGS: A REVISION

Recent science has held that instead of exceptional intelligence, the dog's attunement to humans is what sets it apart (see "Top Talent," page 32). Anthropologist Brian Hare, PhD, at Duke University in North Carolina, is pushing back. His new study in the journal *Animal Cognition* suggests that working dogs involved in tasks from sniffing bombs to aiding archaeologists at digs to herding livestock may "have evolved socio-cognitive skills that mimic or, in some cases, rival even our closest primate relatives."

2

THE SCENT OF A GERM

A group of researchers from Columbia University has trained dogs to detect SARS-CoV-2 (the COVID-19 virus) in a second—and with a high degree of precision (for more, see "The Nose Knows," page 62). The researchers trained six dogs, from three different breeds, to detect SARS-CoV-2 in respiratory secretions of infected patients and evaluated their performance experimentally. They then compared it against the gold-standard PCR test. According to the researchers, dogs were tested on 9,200 samples and they achieved—both independently and as a group—such high sensitivity and specificity that they "could be useful to track viral infection in humans, allowing COVID-19-free people to return to work safely." But will U.S. employees embrace canine monitors on the job?

3

PARTNERS IN A PANDEMIC

As expected, adolescents with pets reported spending more time with them during the pandemic and frequently reported pet interactions as a strategy for coping with stress. On the other hand, dog ownership predicted lower levels of loneliness prior to but not during the pandemic. Sometimes there's no substitute for other humans, not even a beloved pet.

4

THE OBJECT OF THEIR AFFECTION

Scans show that dogs' brains light up with emotion when a familiar human face comes into view. Researchers from Auburn University in Alabama found reaction across the emotional, memory and reward centers of the brain: the caudate, hippocampus and amygdala.

IN A BOON TO COGNITIVE SCIENCE, CANINE COLLABORATORS HAVE BEEN TAKING STAR TURNS IN THE LAB.

5

SLEEPLESS NIGHTS

It turns out that dogs, like humans, can be insomniacs. In dogs, sleep can be affected by several conditions, including narcolepsy; disruption of REM sleep, where dreams are recorded; and irregular or disturbed breathing. If your dog has trouble sleeping, consult a vet before it snowballs into behavior problems during waking hours.

6

PRESCHOOL COMPANIONS

Dogs absolutely help socialize our youngest kids. Researchers from Spain have shown that contact with dogs at home during early childhood can promote more advanced social development in both boys and girls.

7

THE HUMAN-CANINE DYAD

So your dog has troubles? Researchers at the University of Pennsylvania report that therapy for problems from aggression to anxiety resolve with greater or lesser ease depending on *your* personality. Issues resolved more easily when owners were more attached to their pet. If owners were extroverts, canines responded better to therapy for sensitivity to touch. Owners open to experiences? Their dogs were likelier to shake a fear of other dogs. One human personality trait, surprisingly, appeared to hurt canine recovery: Therapy for aggression toward strangers didn't work as well if the owners were conscientious. Perhaps these orderly people unconsciously signaled their reluctance to have other humans interfere.

8

FOLLOW THAT FINGER!

We've long known that dogs grasp the meaning when humans point, a power that has eluded many primates. Now research out of the University of Arizona shows that this nifty skill is hardwired into our pooches' DNA. In a study of 375 puppies who were just 2 months old, the scientists found that the ability to understand pointing developed long before that skill could be taught. In other words, the ability to understand pointing was innate. Of course, some puppies did better on the pointing task than others, and this too was genetic. The scientists showed that more than 40% of the similarity between individual performances in the pointing experiment could be attributed to relatedness (similarities in the genes). It seems that following the intent of humans—like personality itself—is a skill dogs may be born with, to a greater or a lesser degree.

HOW DOGS

(AND CATS)

BY STAN HORACZEK

SEE THE WORLD

OUR PUPS' OTHER SENSES MAKE UP FOR THE FACT THAT THEY CAN'T PERCEIVE SOME COLORS.

TAKE A QUICK FLASH PICTURE OF YOUR DOG, AND HER EYES WILL LIGHT UP IN A WAY THAT'S EQUAL PARTS COOL AND UNNERVING.

That eerie glow comes from a layer of their eyes called a tapetum, and it reflects light in order to let our furry pals, dogs and cats alike, see small amounts of light much more efficiently than our human eyes do. In fact, our pets sense the world in which we live in a way that's far different from ours.

As children, many of us learned that cats and dogs are "colorblind" or see the world in "black and white," but that's not entirely true. "They [just] can't see all the different colors that we can see," says Katherine Houpt, VMD, PhD, a professor at Cornell University College of Veterinary Medicine in Ithaca, New York. "From what we can tell, they see the world in shades of blue and yellow."

From a physiological standpoint, their unique view comes down to the types of light receptors in the eye itself. Because canines and felines are predators, they don't have to be able to tell the difference between some similar shades, Houpt explains. "As primates, we have to know whether that persimmon is ripe or not. We're better at color discrimination in order to find the correct foods." In other words: To predators, a gray rabbit is just as tasty as a brown one.

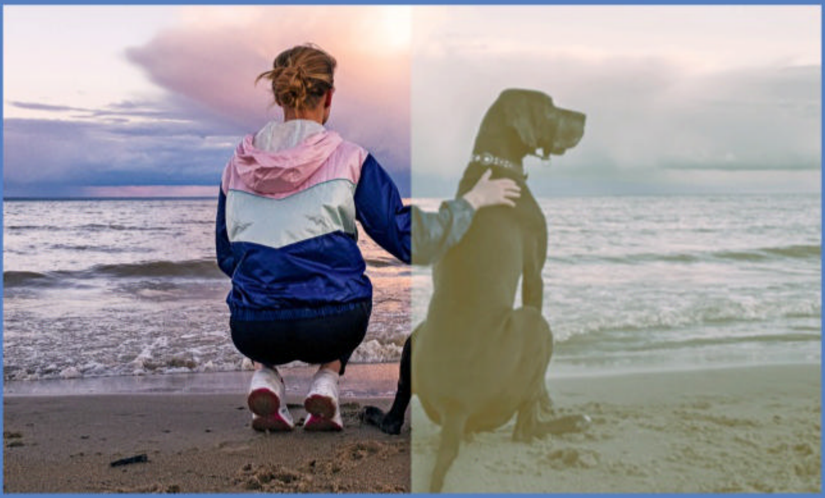
When it comes to clarity, humans also have an advantage over our domesticated pals. If a dog can make out an object from 20 feet away, a human can see it from 60 feet. (The difference is even more pronounced for cats—what a cat can see from 20 feet, a human can see from 100 or even 200 feet out.) Our pets aren't built to process crystal clear images of the world around them.

The animals do have an advantage, however, when it comes to perceiving movement—a skill honed to help them catch their fast-moving food. While most cats and dogs have trouble spotting still objects very close to them, they can spot movement for up to a half-mile—even if it's relatively subtle.

Dogs and cats can also see more at once than humans. While our field of view is approximately 180 degrees, feline and canine eyes bulge out a little, to expand their peripheral vision past 200 degrees. That same motion detection extends to the edges of their vision, so even if they can't tell what's moving, they know something's coming—and from where.

However, that field of view can differ, depending on the breed of dog. A bulldog, for instance, doesn't have to see around a giant snout, like some other breeds, which comes in handy when observing objects up close and gives them a bigger overall field of unobstructed view.

One commonly held conception is true: When it comes to seeing in the dark, cat and dog eyes excel—in part, because the tapetum reflects illumination to the light receptors. "They can't see in absolute darkness any better than we can," says Houpt. "But in dim light, they can see better." That's because their eyes contain more rods than ours—between six and eight times more, for cats—which means they require less illumination to collect a usable picture for their brain.



But the uncanny perception doesn't end there. Once you've considered all the advantages and shortcomings of cat and dog vision, you still have to consider the interplay with their other senses.

Cats can hear the ultrasonic pitches typically emitted by their prey—which allows them to continue the chase, even if their scurrying snack scurries out of eyeshot. They also use smell as a primary method to identify people. "When you take a cat to the vet, your second cat may not recognize it because it smells like other people. And if you've been gone for a while and come back, the cat may not recognize you until it takes a good whiff," Houpt says. "If you changed shampoos while you were gone, you might be in for a problem."

Dogs obviously have a keen sense of smell as well. Like cats and other animals, they have a vomeronasal organ as part of an olfactory system, specifically dedicated to their needs, that allows wilder things to communicate via scent and improves the overall sense of smell. (Read more in "The Nose Knows," page 62.)

With those extra tools at their disposal, dogs and cats don't need to depend on their eyes to navigate the world. Their visual limitations, however, can pose some interesting problems for humans trying to teach animals new tricks.

"Because of how they see color, dogs are not very good at traffic lights," Houpt says. "That becomes a problem when you're teaching a guide dog, so they have to learn that the darker yellow is when they have to stop." In an ideal world, she adds, traffic lights would have an olfactory component so that helpful pooches could smell when they must stop and when it is time to cross the road.

DOGS AND HUMANS SEE THE WORLD DIFFERENTLY. DOGS' VISUAL ACUITY EVOLVED TO MEET THEIR UNIQUE NEEDS, AND DIFFERENT DOESN'T MEAN BETTER OR WORSE.

SHORT-NOSED DOGS USUALLY HAVE BETTER VISION UP FRONT WHILE LONG-NOSED DOGS SEE BETTER AT A DISTANCE, SPECIALIZING IN PANORAMAS. THEY EXCEL AT FRISBEE.

THE NOSE KNOWS

IT CAN SNIFF OUT CANCER, WEEDS AND BOMBS. SCIENTISTS ARE FINDING THAT THE DOG'S SNOUT IS A NEW FORM OF TECH.

DOGS SEE and hear differently from humans, but their inner world differs most radically from ours in the realm of scent. Compared to dogs, humans are practically nose-blind. Where humans have roughly 6 million odor receptors in their nasal passages, dogs have anywhere from 100 million to 300 million receptors, depending on the breed. They also have more types of receptors, so they're able to detect some kinds of odor molecules that our noses simply ignore. The difference is so vast that it can be hard to imagine what odor means to the inner experience of dogs. For them, everything—and everyone—has a unique scent. A dog can sniff the difference between identical twins and smell the chemical changes in your body that indicate sadness, stress or fear. They can smell the places you've been on your shoes and clothes as well as the things you've eaten for lunch, down to every last menu item. Your dog can detect the scent of the cat you stopped to pet and the flowers you picked up on your way home from work. Some dogs and dog powers are especially extraordinary—and in the three stories ahead, we cover some of the world's top smellers, along with the technologies and endeavors they spawn.

A TRAINED DOG DERIVES A VAST ARRAY OF INFORMATION ABOUT THE WORLD, THANKS TO ITS ASTOUNDING SENSE OF SMELL.

LIFESAVERS

smelling bombs

3D-printed dog snouts ace the act of detecting TNT.

DOGS HAVE used their incredible sense of smell to help us find missing people, corpses and drugs; they even aid conservation efforts by sniffing out koala poop. Now their powerful noses may inspire better tools for detecting traces of explosives in crime scenes, war zones and more.

It turns out that dogs sniff in such a way that scent-filled air is pulled toward their nostrils as they exhale. In one recent experiment, researchers managed to copy this skill: When a chemical detector was fitted with an attachment that let it “sniff” like a dog, it became better at picking up traces of the explosive TNT.

“You start reaching out and kind of pulling this vapor to the inlet,” says Matthew Staymates, a mechanical engineer at the National Institute of Standards and Technology in Gaithersburg, Maryland, and a leading researcher in the work. Sniffing may “improve our ability to get the sample from the air to our analyzer.”

We’ve long known that dogs can pick up whiffs of scent far too faint for a human to detect. The canine nose is, after all, packed with hundreds

BOMB- AND DRUG-SNIFFING DOGS ARE TRAINED TO RECOGNIZE CERTAIN SMELLS THROUGH CONSTANT REPETITION AND REWARD.

of millions more olfactory receptors than we have. But it turns out that the mechanics of dog sniffing is critical as well; what happens *outside* a dog's nose while it smells is clearly important too.

To examine the aerodynamics of dog sniffing, Staymates and his colleagues made a 3D-printed model of a female Labrador retriever's nose. The snout was fitted with a piston-cylinder device, allowing it to mimic a dog's inhalations and exhalations. "It sounds just like a dog sniffing," Staymates says.

Using a technique called schlieren imaging, the researchers could see wafting vapors as a sniff pulled them in. Dogs, it was discovered, sniff about five times per second. Every time a dog breathes out, it sends little jets of air down and outward. And these jets, in turn, then draw fresh air back toward the dog's nose.

"He's literally reaching out in front of him and pulling a plug of new air toward himself," Staymates says.

The way dogs sniff summons air that would otherwise stay out of their nostrils' reach. The scientists found that their 3D-printed nose was better at detecting odors when it actively sniffed and inhaled air in stops and starts as opposed to sucking in air in a steady stream, "as if it had infinite lung capacity," Staymates says. On the other hand, the chemical detectors we use now sample air by pulling it in continuously, limiting the ability to grab vapor molecules floating in the air.

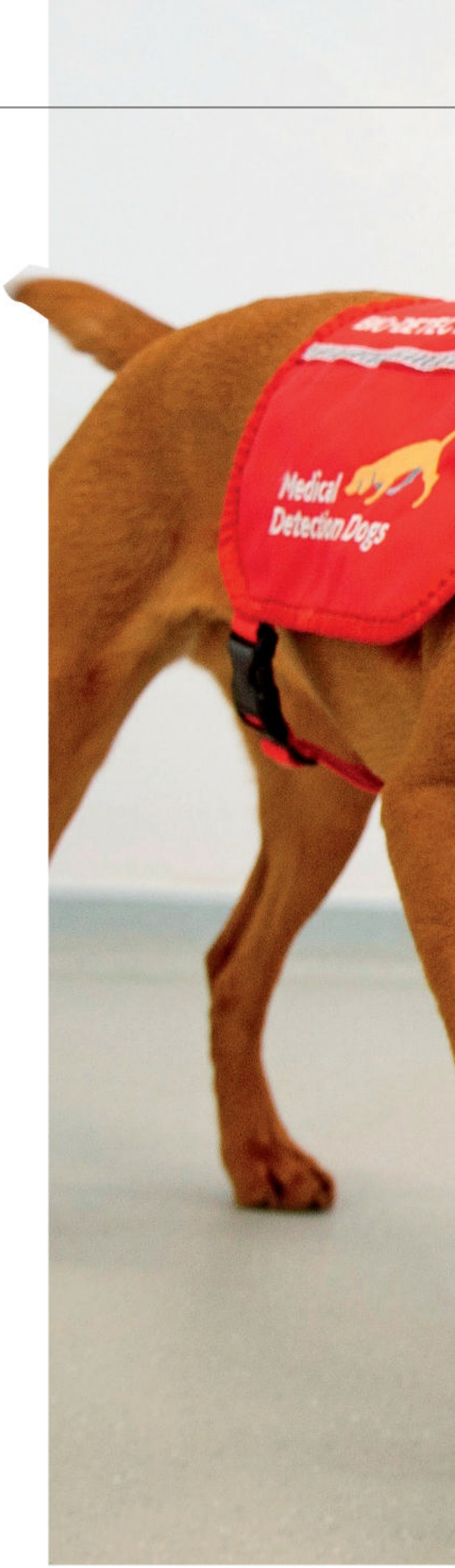
Encouraged by the fake nose's success, he and his team designed a pair of little air jets to clip onto a commercially available chemical detector. The jets "are acting like two nostrils—pulsing air in one direction, just like the dog does," Staymates says.

The chemical detector was up to 16 times more effective at detecting TNT it "sniffed" instead of inhaling.

The jets in the artificial 3D snout weren't much help when the detector was placed very close to the vapor source, which was a can of gelatin laced with a small amount of TNT. At close range, the artificial nose actually blew the vapors away. But farther away, the printed, aerodynamic "nose" improved upon traditional detection technology.

"We're not proposing that the next generation of vapor detectors have something that looks like the nostrils of a dog on it," Staymates says. But "there might be a smarter way to do it, by controlling the airflow and almost forcing air to brush across the surface." *—Kate Baggaley*

IN THE AGE OF PANDEMICS, DISEASE-DETECTING DOGS COULD STOP INFECTIONS FROM CROSSING BORDERS AND TRAVELING THE WORLD.



BIO SLEUTHS

smelling germs

Canines may be able to help us fight diseases.

MALARIA IS a global problem, still infecting hundreds of millions of people and killing more than 400,000 a year. Recently, a team at the London School of Hygiene & Tropical Medicine have found that dogs can detect the malaria parasite, even in people who show no signs of the disease.

The discovery makes sense. Researcher James Logan, PhD, and his colleagues found that the malaria parasite gives off a distinct perfume of aldehyde compound, which mosquitoes happen to love. If mosquitoes can home in on these compounds, why not dogs? It's not a crazy idea—dogs are already known for sniffing out cancer. Logan says that dog sniffers could be faster and less invasive than current diagnostic tests, which involve taking blood samples and analyzing them with special equipment. And if the dogs were used to detect the smell on people without symptoms of malaria, it would be possible to stop those individuals from spreading malaria unknowingly.

To explore the idea, Logan's team collected socks worn for 12 to 24 hours by children in Gambia, some of whom had no malaria infection while others were infected but showed no symptoms. The scientists brought the socks back to the U.K. and froze them while they trained two dogs to identify the malaria smell. Several months of training later, the dogs correctly identified 70% of the malaria-infected children and 90% of the malaria-free children, just from smelling their socks.

"We were genuinely surprised with how well it worked," says Logan. "We knew dogs were able to smell cancer, and we thought it should work...but this is a very tough test." The research isn't yet ready for widespread use, says Logan. But the researchers will be expanding the work, with more dogs recruited to perform sniff tests on actual, live human beings.

Meanwhile, Logan and his team are investigating the idea of using dogs at airports and borders to sniff out humans infected with COVID-19. In an article recently published in the *Journal of Travel Medicine,* Logan and colleagues contend that COVID-sniffing dogs might be more efficient in detecting the disease than the infrared thermal image scanners previously used for such jobs. —*Jillian Mock*

inside the dog's nose

In dogs, a portion of the air that's inhaled goes directly to a recessed area in the back of the nose, which opens into the upper part of the mouth (called the vomeronasal organ or Jacobson's organ). This organ processes odor, while the rest of the air flows down to the lungs. The membrane that absorbs odors spreads across a maze of bones, called turbinates, and routes various molecules based on their chemical properties. This allows dogs to detect different strains of odor that make up one entire scent. Cellular receptors for those molecules transform them into electrical signals that travel to the olfactory center of the canine brain to be analyzed. The part of a dog's brain devoted to scent is around seven times greater than the corresponding center in a human brain. And depending on breed, the dog's nose is anywhere from 10,000 to 100,000 times more sensitive than the human nose. Thus, a dog experiences the world largely through scent, while humans rely more on sight. But this doesn't mean that scent replaces vision for dogs. Visual and auditory senses are still critical for dogs when navigating life.

ONCE CONSERVATION DOGS IDENTIFY PLANTS THAT UPEND THE BALANCE OF AN ECOSYSTEM, HUMANS CAN REMOVE THEM.

GARDENERS

smelling invasive species

Dogs can sniff out troublesome weeds and other pests.

LILY IS a golden retriever from Georgia. Seamus is a border collie from Montana. Together, they are leading a Working Dogs for Conservation team, to eradicate an invasive weed from Mount Sentinel in Missoula, Montana.

Before the team of dogs took over, humans were doing a mediocre job of controlling dyer's woad, a knee-high, light-green weed native to southeastern Russia. The problem lay with how people usually identify the plant—by its distinctive yellow flower, which lights up roadsides across the southwestern U.S. The golden blossoms might be pleasant on the side of the highway, but dyer's woad crowds out native plants from Arizona to Wyoming. "They displace multiple species within the native plant community," says Jane Mangold, PhD, a professor of land resources and environmental science at Montana State University. "A general loss in biodiversity ensues."

However, by the time the bloom is easily visible, it's already too late; the dyer's woad has reproduced.

That's where the dogs come in. In 2011, Lily and Seamus made their first forays into the Montana brush, sniffing out the offending weeds. They were able to point out hundreds of plants that humans missed. The dogs kept coming back, since dyer's woad can last for years in the soil. In 2017, they found only four plants, having nearly eradicated the tricky weed, says Pete Coppolillo, executive director of Working Dogs for Conservation.

Like dogs trained to sniff out cancer, bombs, drugs and even the flu, the conservation dogs can detect what humans cannot: kit foxes in California's San Joaquin Valley, gunpowder in Zambia, invasive brook trout and mussels in Montana, a cattle-killing bacteria in Yellowstone National Park.

But none of this is surprising, because *of course* dogs have the advantage when it comes to sniffing out invaders. In a side-by-side comparison, dogs would beat their primate best friends at a smelling contest every time—right? Not necessarily. "From a scientific point of view, there's not a lot of evidence of how sensitive the dog's nose is," states Matthias Laska, PhD, a professor of zoology at Linköping University in Sweden. He notes that scientists have tested only 15 scents on both dogs and humans, depositing tinier and tinier amounts of each until they found exactly how much each species could detect. The humans were actually better at smelling five of them. "This statement that dogs are the undisputed supernoses of the universe is simply not true," Laska contends.

Dogs perceive the world differently from us and rely on their olfactory sense more than humans do. They use their noses to identify one another and navigate the world—humans do not usually go around sniffing each other. Dogs devote more of their mental resources to their sense of smell, according to Alexandra Horowitz, PhD, a psychology professor at NYC's Barnard College, in her book *Inside of a Dog: What Dogs See, Smell, and Know*. Their olfactory bulb takes up about an eighth of their brains, a larger percentage than our visual cortex takes up in ours. However, in a *Nature Neuroscience* study, both species did an equally accurate job of following the trail of a desirable scent through a field, though the dog tracked a dead pheasant and humans followed chocolate essential oils. Both the pups and undergraduates became better trackers, with practice.

And working canines *do* practice. Working Dogs for Conservation screens 1,000 shelter animals for every one dog they put into training. And half of those fail out of pup smell school. The best dogs are energetic and highly motivated by toys, Coppolillo says.

Scientists have never made dogs sniff the air for illegal bush meat or marijuana while standing on their hind legs, human-style. But perhaps they would be able to detect these scents, and many more, under human behavioral restraints. "If we consider that every item has an odor, then given dogs' olfactory acuity, we can expect that dogs could be trained to tell us when they detect pretty much anything," says Horowitz. But researchers have also never forced humans to track hundreds of smells through airports or the Serengeti. And until they do, we have no way of knowing just how superior Lily and Seamus' smelling powers truly are… or what *Homo sapiens* could achieve in this sphere. —*Ellen Airhart*

GHOSTW

HOW TO UNDERSTAND THE SLOW-MOTION SLINK OF YOUR DOG IN A TRANCE.

BY ANNA BROOKS

ALKERS

CAROLINE COILE, PhD, noticed her dog behaving strangely. Her saluki, a slender sight hound named Bibi, kept sneaking into the closet. Inside the dark, enclosed space, Bibi—normally a sprightly dog—slunk around in excruciatingly slow circles as the hanging clothes dragged delicately across her back.

Coile—a researcher specializing in canine genetics and behavior at Florida State University—brushed off the behavior as just a quirk of Bibi's until she caught her next dog, another saluki, doing the same exact thing, years later. This time, the love affair was with a backyard bush. The dog moved like a chameleon, one sluggish, rocking step at a time, letting the drooping plant leaves trail across his back.

"At the time, we had no idea what it was. We would just say, 'Oh look, he's doing slow-mo dog again!'" says Coile.

This slow-motion slink is known as "trancing"—sometimes called ghost walking—and is most common in bull terriers and greyhounds. But the strange behavior worried some pet owners. Were their dogs having seizures? Was it some form of obsessive-compulsive disorder?

Trancing is definitely weird, but Coile says that it's not an indication your dog is suffering from an undiagnosed neurological condition. In fact, one study published in *Veterinary Record* found trancing to be "apparently purposeless."

"It's not like they're in an actual trance, where they're looking into a crystal ball or something," she says. "But it does seem like they go into some sort of meditationlike state."

For those who've witnessed a dog trance, it certainly seems like your four-legged friend has left this earthly plane for somewhere more psychedelic. Once the object of the trancer's desire is spotted—typically something hanging, like plant leaves or curtains—the dog creeps beneath it, ears completely flat, nose pointed up, eyes squeezed shut in what looks like utter ecstasy.

But why the heck do dogs trance or ghost walk? Coile has one theory: It just feels good.

"I think, obviously they very much enjoy it," she says. "If you happen to interrupt them, they always look at you like, 'Really?' And then they trot away in disgust. It's a sort of thing they enjoy doing by themselves."

Alice Moon-Fanelli, PhD, a certified animal behaviorist from the Cummings School of Veterinary Medicine in Boston, stumbled upon trancing while studying compulsive tail-chasing in bull terriers.

The odd, unfamiliar behavior troubled her. Bull terriers are a breed that suffer from debilitating doggy OCD, also known as canine-compulsive disorder (like humans, dogs can behave compulsively; unlike humans, they don't experience the high level of obsessive thinking that's found in people with OCD).

There have been cases of tail-chasing in bull terriers so severe, the dogs were euthanized. Owners reported that some dogs wouldn't stop, even to go to the bathroom, and others wouldn't eat. Some would injure themselves or got so aggressive with humans who interrupted their twirling that owners had to put them down. Moon-Fanelli worried that trancing was yet another manifestation of compulsive disorder in the breed.

But trancing appeared to be unrelated, and on further study, the behavior seemed completely harmless—if still abnormal. "The bull terriers would go under Christmas trees, curtains, towels...anything hanging that would cause dorsal stimulation," she says. "Their eyes glazed over, and they would go into this slow moonwalk. Then they'd come out of it and be fine."

Trancing seems to be unique to dogs, and for reasons yet to be determined, bull terriers and greyhounds lead the pack as top trancers. Coile says that she believes trancing runs in breeds, but there's no evidence the behavior is hereditary. So far, all dog experts know is that trancing is totally a thing—but what type of thing is still unknown.

So if you catch your dog sneaking off for some alone time with your favorite houseplant, there's no need to panic. Your pup is just having a good time...and maybe meditating on the very nature of existence. Or at least the nature of treats.

canine choreography

LEARN TO READ YOUR DOG'S BODY LANGUAGE.

BY JILLIAN BLUME

OVER THOUSANDS of years of domestication, dogs have developed a silent, deliberate language in order to communicate with humans. While vocalizations play a small part in their attempt to talk to us, a dog's body language speaks volumes —if only humans knew how to translate.

Imagine living in another country, where you don't understand a single word and literally no one speaks your language. That's a dog's reality every day of their lives; one of the most compassionate actions we can do for our dogs is to learn how to read their body language. Not only will it provide insight into your dog's personality and needs, but it will go a long way to keep you both safe: The failure of humans to read a dog's body language is the root of the majority of dog bites.

There are seven major areas of the body with which a dog tries to communicate: eyes, ears, tail, mouth, hair, sweat/panting and body posture. You must observe each of these areas in order to decode the secret language of dogs. But to correctly translate, each part of the body must be read in relation to other parts, to understand what your dog is trying to say.

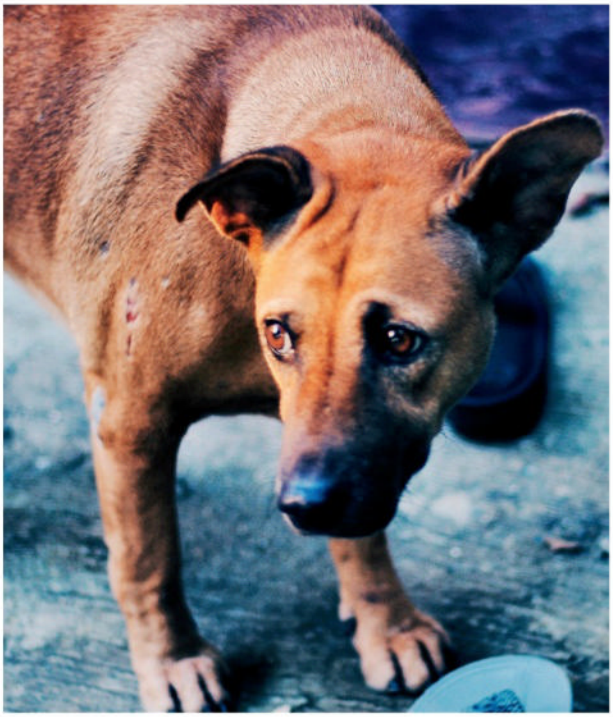
A SOFT EXPRESSION AND BLINKING EYES SHOW THAT YOUR DOG'S AT PEACE.

mellow

Hard-core dog lovers like to love on all pups everywhere—but not all dogs appreciate or are ready for interaction. Look for a relaxed stance, with the dog's weight distributed across all four feet, which should be flat on the ground. The mouth will be slightly open, with the corners turned up in a smile and the tongue sticking out. The ears, which communicate with movement, should be in a soft, neutral position, neither pulled forward or back. The tail should be held loosely in a relaxed position, and the coat should be smoot with no hackles raised. The eyes of an approachable dog will be soft rather than staring hard in any one direction; the dog may be looking directly at you but without maintaining eye contact for too long.

fearful

While a dog who is afraid is not necessarily aggressive, he will need to be approached very carefully or not at all, since dogs will bite out of fear. A fearful dog often sits in a tight, crouched, low position to make himself look as small as possible. He may even be pressed flat to the ground. The tail will be tucked between the legs. It may try to back away, with the weight of its body on the back legs. The ears will be back and flattened to the head, and the mouth will be shut and tight. The dog may lick its lips as a self-soothing mechanism, and its face will be tense. You will often see the whites of the dog's eyes (called whale eyes) when the dog gives you a sideways glance.

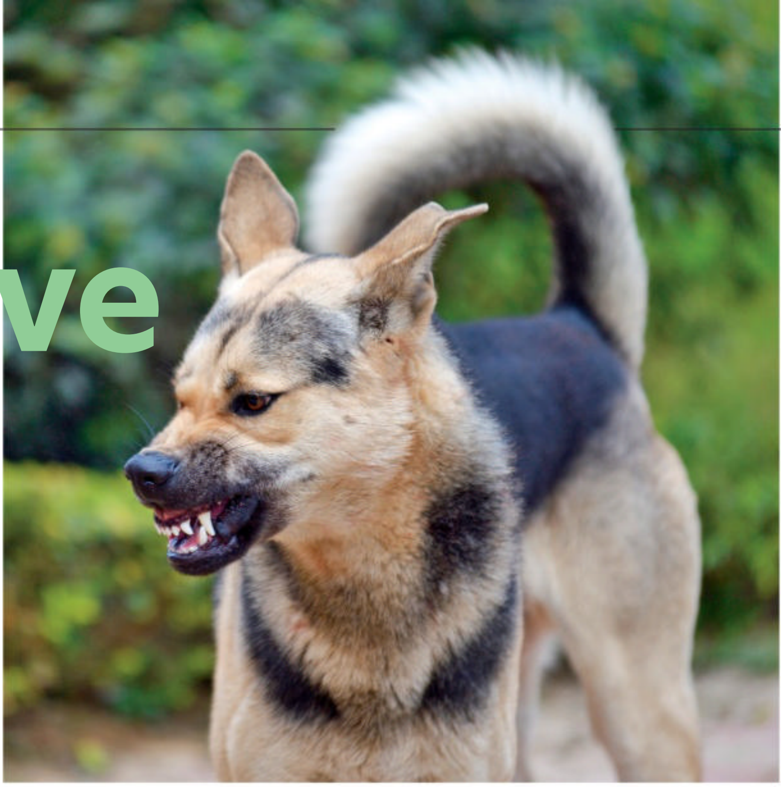


playful

PLAYING BUILDS SOCIAL COHESION BETWEEN DOGS AND HUMANS.

When playing with other dogs or with humans, dogs use specific language that will tell you when play fighting may slide over the line into real conflict. A dog that's feeling playful will wag its tail loosely from side to side; watch out for a motion that morphs into stiff, short wags. One of the most important signals dogs give other dogs when playing is called the "play bow": The dog leans on its elbows, front legs stretched out on the ground and chest low to the ground as if about to lie flat, but its butt stays up in the air. The face is relaxed, and it may look like the dog is smiling. Dogs will often stop in the middle of a romp, to give the play bow to one another as a sign that they're only playing and want to continue.

aggressive



The most important signals of aggression are subtle—and they are the ones that people tend to miss. Take a wagging tail, for instance. A dog wagging its tail isn't always a happy dog; a stiff, upright tail wagging in short, fast movements often precedes a bite. Other signs include a stiff, tense posture, with the weight of the body forward. The ears may be flattened and pulled back or forward and stiffened, and the mouth and lips may be tense. The dog has hard eyes and will look away. The not-so-subtle signs are growling, lips pulled back and teeth bared, as well as barking. A dog about to attack may lower its body, with its weight toward the back, and tilt the head upward, teeth bared.

WHEN YOUR DOG IS ILL AT EASE, HE MAY LEAN INTO YOU FOR SUPPORT.

anxious

Be careful with a dog who is anxious or stressed about a situation or environment. If you make the wrong move, the anxiety may morph into fear aggression. An anxious dog will often lower its head, the ears held slightly back and the neck stretched out, and may back away from people. The tail is tucked under the body, and while remaining low, may wag slowly. The dog will turn its head away or avoid eye contact, perhaps licking the lips (when not hungry) and yawning repeatedly (when not tired). As anxiety rises, the dog may pace, pant and tremble as well as shed or drool excessively.

terrified into submissive

A dog in this state is often emotionally shut down. She won't eat, drink or interact in any way with the environment, people and other dogs. She may sit with her head tucked down or pressed into a wall. This is a posture often seen in dogs in shelters. If approached, she will not make any eye contact. A dog in this state may roll over and bare her stomach and throat, in an act of extreme submission. She may urinate out of fear. The ears are flattened back against the head, the corners of the mouth are pulled back, the lips are tightly closed, the eyes are partly closed. It's very distressing to see a dog in this state!

happy

This is how all dogs should be! A happy, content dog has a relaxed, loose posture. The fur is smooth, and the ears are held at their natural position. A happy dog's mouth is relaxed and often open, with the sides sometimes lifted in a smile. The eyes are relaxed, soft and sparkling. The tail may swish back and forth or even wag in a circular motion, and the dog will sometimes lightly pant with happiness. A content canine will often lie down and may stretch out the back legs in the "frog" (or "sploot") position. This is a dog that is happy to feel the breeze on its face and bask in the sun.

A HAPPY, RELAXED DOG MAY SOMETIMES LOOK HALF ASLEEP.

confident

This is not quite the same as the happy, content dog, though confident dogs are usually happy. They stand tall, straight and still when they meet other dogs, their head held high, ears perked up, eyes bright and sparkling. The mouth is relaxed and may be slightly open. The tail is raised and may move in a slow, wide wag. The dog is friendly, approachable and comfortable in its environment. The confident dog seems born to sit at the head of the table and run the operation.

EARS, TAILS, EYES, HAIR, FEET, POSTURE: OUR DOGS EXPRESS THEIR FEELINGS, HEAD TO TOE.

AUTHENTIC SELVES

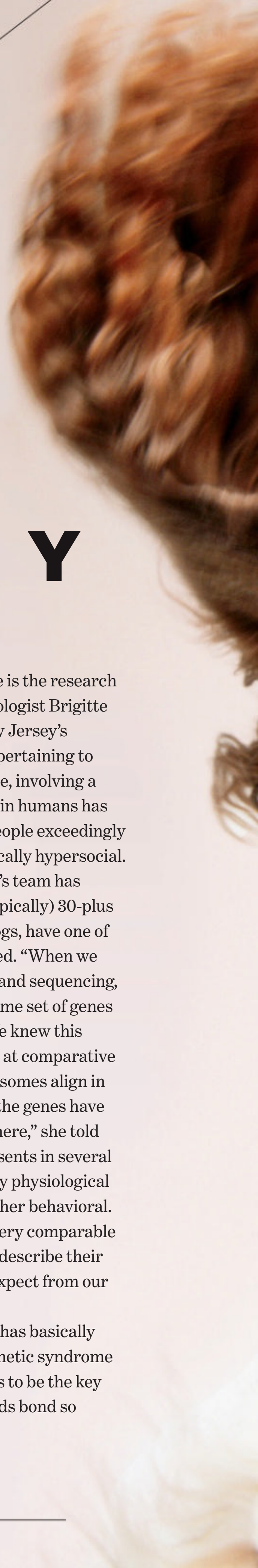
PART 4

EACH DOG IS AN INDIVIDUAL—WITH TASTES, DESIRES AND A PERSONALITY ALL ITS OWN.

THIS DOG'S GOT PERSONALITY

A PUP'S BREED MAY TELL YOU SOMETHING IMPORTANT ABOUT WHAT THEY'RE GOING TO BE LIKE, BUT IT'S JUST A STARTING POINT.

BY MARK TEICH



MY DOG, a cockapoo, wanted the love of every human who came through our door—but shrank from other dogs after mere moments and followed me around from room to room, never wanting to be alone. My cousin Keena's dog, an older Chihuahua, literally shivers when confronted by new people, barks crazily at other dogs and prefers being left alone. And my friend Sam's puppy, a Lab, is calm and self-satisfied in general, doting on Sam's entire family but also happy by himself. Whenever he sees another dog, he thinks it's playtime—time to run circles around each other, faux-nip and wrestle. What accounts for these personality differences? Is it breed and genetics, upbringing or just the luck of the draw?

Turns out, it's all of the above and then some. Here's what the experts say are the key elements that help shape a dog's personality.

Breed and Genetics

Recent research suggests that a dog's breed and genetics may be responsible for as much as 40% of its ultimate personality. Some of the most exciting news in canine science is the research led by evolutionary biologist Brigitte vonHoldt, PhD, at New Jersey's Princeton University pertaining to the Williams syndrome, involving a complex of genes that in humans has been found to make people exceedingly nice and friendly, basically hypersocial.

Professor vonHoldt's team has found a complex of (typically) 30-plus genes that, in many dogs, have one of their two copies deleted. "When we did genetic screening and sequencing, we came across the same set of genes that are in humans. We knew this because when we look at comparative genomics, the chromosomes align in the same fashion and the genes have the same sequences there," she told us. "That deletion presents in several clinical forms, one very physiological and biomedical, the other behavioral. And that behavior is very comparable to how people usually describe their dog or the things we expect from our companion dogs."

In other words, she has basically found the Williams genetic syndrome in dogs, which appears to be the key to why many dog breeds bond so

SOME BREEDS NEED HOURS OF EXERCISE AND EXCITEMENT EVERY DAY TO BURN UP ENERGY. WITHOUT ENOUGH STIMULATION, THEY ARE LIKELY TO DEVELOP BEHAVIOR PROBLEMS.

strongly with humans and show us so much love. It also gives us a hint of the evolution from wolves to dogs. Most wolves do not have this complex of genes. But surprisingly, when her group did studies comparing wolves and dogs, they actually found that even some wolves could be fairly friendly to humans—and virtually all those wolves had the same complex of genes with deletions that make certain humans and dogs so friendly and social.

Unfortunately, some negative personality factors also have a strong genetic component. "When it comes to fear and anxiety-related problems, genetics is important," says Carlo Siracusa, DVM, PhD, an associate professor of animal behavior at the University of Pennsylvania Veterinary School of Medicine (Penn Vet). "I tell clients that while this is not 100% proven or predictive, if you have a dog that is very fearful—whether male or female—it should not be bred, because recent research shows that a significant proportion of fear and stress responses are determined by the parents."

Pregnancy and Birth

Many formative factors vital to a dog's lifelong personality occur in the period between conception and shortly after birth.

CONCEPTION The condition of the father at conception plays an important role in who a dog will be. A recent rodent study shows that males in good health who live in nonstressful environmental conditions will produce healthier sperm than those who are stressed at conception—and this can help to determine both the physical and mental well-being of the offspring.

SIZE AND APPEARANCE ARE IMPORTANT FACTORS IN HOW PEOPLE RESPOND TO A DOG, AND THAT, IN TURN, CAN AFFECT THE DOG'S BEHAVIOR.

GESTATION What happens in the womb is important. Like the health of the father's sperm, the mother's health affects the baby. A puppy will generally be born healthier and more positive if the mother is healthy and unstressed.

BIRTH "Whether puppies or babies are born through C-section or normal vaginal birth makes a difference," says Siracusa. "A lot of the personality of an individual is determined by the host microbiome, all the bacteria that live in the mommy's gut, and these will influence the puppy's immune response—which, in turn, will influence behavior. A lot of the good bacteria that colonize our gut are in the vaginal mucus, but in the C-section, there is no exposure to these microbiota, and evidence suggests that the offspring will be left more anxious and stressed."

AFTER BIRTH The mother's nurturing or nonnurturing behavior toward the baby in the moments immediately after birth, especially during the time that's spent licking the new infant, will influence the puppy's sense of self and future behavior.

Socialization

The first three to 12 weeks after a dog's birth, often before future owners ever see the puppy, are the most sensitive period for socialization and are key in the development of the canine's personality.

"The puppy needs to be exposed to the right stimuli in this period, stimuli well-known and prescribed today by breeders and trainers," says Siracusa. "You have to introduce the puppy to experiences that are new but below the threshold for fear and trauma."

Programs now exist to orchestrate this socialization, which includes meeting other animals, walking around the home, taking walks, perhaps even taking car rides—the kinds of experiences puppies will encounter once they are "re-homed." But a puppy can't just be randomly brought to a chaotic market, say; the exposure has to be controlled and perceived as safe so it will have positive associations. "If you expose a puppy to a stimulus so intense that it triggers a fear response, you will do more damage than good," Siracusa says.

Physical Problems

If a puppy suffers from a physical problem, such as a skin disease with chronic inflammation, it can lead to negative behavior. "The microbiota [the bacteria that live in our gut and skin] influence the immune system, and the immune system, in turn, influences both physical health and behavior," says Siracusa. "The physical problem causes discomfort that makes the animal nervous, and animals with chronic inflammation tend to have stress-related behavior problems. The mediators of inflammation that can lead to fever also get into the brain, targeting regions that affect behavior."

Dogs with compulsive behaviors like excessive urinary leaking, he notes, often actually have a chronic gastrointestinal problem, and dogs experiencing pain are more likely to show an acute onset of aggression. In fact, the new aggression may be the only sign of the pain, a true red flag of a medical problem. The important thing in these situations is to get the dog to a vet as soon as possible; controlling the physical problem is key to improving behavior. "It's vital to have intervention early, when the brain is plastic and open to modification," says Siracusa.

Home Environment

The atmosphere in a puppy's new home can have a huge impact in enhancing or hurting socialization, sense of self and personality. "For example, if a dog is introduced very early to a family where there is a lot of arousal—say there are children and people always running around and the dog has a problem finding a quiet spot to cheer up—this constant overstimulation can influence personality long-term," notes Siracusa. "It can leave the dog with an inability to calm down." 🐾

when i met the world's smartest dog

CHASER WASN'T JUST LEARNING OBJECTS BY NAME: SHE WAS GRASPING CONTEXT AND BEGINNING TO UNDERSTAND THE BASIC STRUCTURE OF HUMAN LANGUAGE.

BY DAN NOSOWITZ

"CHASER, THIS is Dan. Chaser! This is *Dan*," said Deb Pilley, a classical musician who goes by the name Pilley Bianchi professionally and signs her emails as "Pill." Pill is the daughter of John Pilley, a former professor of psychology who owned Chaser, an average-size border collie mostly the color of cookies-and-cream ice cream. Standing in the entryway of Pill's apartment, Chaser looked up at me with round amber eyes. "Hi there," I said as I stuck my hand out for Chaser to smell. She did, briefly, glanced at Pill, then turned around and ran upstairs to Pill's apartment. The introduction was not dissimilar to a lot of introductions I've had at parties, except this time, I was meeting a dog.

Border collies are the only dogs I like. They are herders, bred hundreds of years ago to work with sheep around the Anglo-Scottish border. They're highly energetic but focused; they are, unlike many dogs, workaholics. In the absence of herding tasks, many, including Chaser, decide that their "job" is to play fetch. They'll do it for hours, every day, and if they're not allowed to "work" enough, they get bored—and then they get destructive.

Pill has a magnet on her fridge that says, "My border collie is smarter than your honor student." It's not *quite* true—Stanley Coren, author of *The Intelligence of Dogs*, estimates that a very bright dog, like Chaser (who sadly died in 2019), possesses the intelligence of about a 2.5-year-old child. But I wanted to see just how smart she was.

Throughout the interview, Pill gave Chaser what I considered to be some pretty intricate directions. It was never "sit" or "stop," but things like "relax" or "go to the living room," which Chaser actually obeyed. These weren't to impress me; this is the way Pilley, his wife, Sally, and Pill talk to Chaser.

But I wanted to see some tricks. I was given a plush donut-shaped toy—the name of which, I was told, is Fuzzy. My first task: Hide Fuzzy and have Chaser find it.

"Find" is a difficult test for an animal, because it is entirely based on the spoken word. It requires that the object to be found not actually be in sight. "Fetch" allows the dog to see the object as it's thrown, unlike "find."

I hid a toy called Fuzzy under a tall piece of wooden furniture, tucked way in the corner. There were only a few inches of space underneath; Fuzzy wasn't really in sight at all. It was too good a hiding place. Chaser understood the task, but she got frustrated quickly, almost like a toddler.

After a minute or two of Chaser scouring the apartment for Fuzzy, Pilley told me to play the hot and cold game. "Seriously? She understands 'hot' and 'cold'?" I asked. "Oh, yes," he said. As she got closer to Fuzzy, I said "Hot, Chaser! You're getting hot!" She got more excited at this and began more energetically searching around that area. Just in case, she turned around briefly. "Cold, Chaser!" I said. She quickly turned back around and, within a few seconds, had triumphantly located Fuzzy.

All the border collies I've known have played fetch in this way, but I had never met one quite like Chaser. Her favorite toy and fetch object was a bouncy blue ball, which was named Blue. Chaser sat a couple of feet from me during the interview and very gently and precisely rolled the ball at me with her nose. No games, no nonsense: Here's the ball back. Throw it again, please.

That need to work is key to understanding how Chaser had been able to learn more human language than nearly any other nonhuman primate that we know of. Chaser knew upward of 1,200 words—not just nouns but also verbs and modifiers like adjectives and prepositions. Pilley had trained Chaser in an almost evolutionary way, looking at the specific needs and behaviors of the border collie breed and adjusting the teaching method to best suit it, doing so largely without food as a reward.

After watching border collies do the work for which they were bred—herding sheep—he noticed that the dogs were able to identify individual sheep by name. The farmers were able to tell their border collies to circle and guide specific sheep, without visually referencing them at all. *If it works for sheep*, thought Pilley, *why not for other things as well?*

His approach was to teach behaviors—verbs, essentially—first and then make sure that the words actually had value to Chaser. "We know that herding is the primary instinct [for this breed], but there are many roles. Sometimes they have to find the prey, herd the prey, attack the prey or kill. So anything that reinforces any of those behaviors is innately reinforcing," he explained. Pilley adapted his reinforcements to suit what the border collie breed is bred to do. According to Pilley, Chaser couldn't learn just anything, but the "find" command, which is much more complex than, say, "sit," was a behavior that was bred into Chaser. The act of finding something, in Pilley's words, had value to Chaser. So no food rewards were necessary; Chaser was fulfilled by the task itself.

Each of the thousand or so objects Chaser knew had an individual name. These were usually whimsical words, like *fuzzy* or *flip-flopper*. But to Chaser, they might as well have been the names of sheep. Chaser also retained the names of objects after learning them, even if she hadn't seen them in years. The idea of naming individual objects and teaching a dog to identify them isn't that new, but with Chaser, Pilley took it to an extreme.

What really excited Pilley was the idea of teaching Chaser other elements of language: how words interacted, how one word could modify another and how words could signify more than one thing. Chaser was the first known dog to understand the concept of categories in human speech. If you told her to "fetch ball" and had set aside a ball, even if she had never seen that particular ball before, Chaser would understand that the word *ball*, for her, referred to something round and bouncy.

!

JOHN STEINBECK CLAIMED THAT HIS POODLE, CHARLEY, UNDERSTOOD ENGLISH AND FRENCH.

NO OTHER SPECIES BESIDES HUMANS HAS DEMONSTRATED THE ABILITY TO LEARN THE MEANING OF WORDS SO QUICKLY AND SO FLEXIBLY.

Bug Box
FRIENDS
COACH

what canine smarts really mean

Ranking canine intelligence across breeds is tricky, but psychologist Stanley Coren, PhD, has tried to do just that by looking at working capability and obedience. He tested how quickly each breed could learn a command and how consistently each could demonstrate that knowledge. The border collie ranked highest and the Afghan hound the lowest, but Coren is quick to note that intelligence is not any one thing and his ranking applies only to the ability to respond to commands. The beagle, for example, ranks seventh from the bottom—a pretty dumb breed, according to the list. Yet these types of commands don't play to the beagle's strength; a member of the hound family, the beagle was bred as a hunting dog, trained to perform one task. Beagles are single-minded and determined when tracking down a scent, but that was all they've ever had to do; it was never necessary for them to understand and distinguish between multiple verbal commands. A border collie's job, herding, is quite complex: Move sheep from this place to that place, keep a herd in a certain area, separate one sheep from the herd, divide the sheep into multiple groups, bring individual sheep to the herder. In short, if your dog excels at devotion to you, that's the kind of intelligence that counts most.

Branching off from that was Chaser's ability to make inferences. Say you set out three objects for her: one is a Fuzzy, one is a flip-flopper and one is a New Balance sneaker. Chaser knew the first two objects by name, so if you told her to "fetch New Balance," she could analyze the three for a second and then gently grab the sneaker and bring it back to you, because she had figured out that this weird object was the only thing that could possibly match up.

I had never met an animal like Chaser before. Throughout my time with her, I distinctly got the sense that she was thinking, not just reacting. When Pill told Chaser to "meet" me, she wasn't being cute; Chaser looked at me, did her version of a handshake, noted that I was a human with whom she might interact and then left.

Chaser seemed to almost be vibrating internally; even when, after being instructed to "relax," she'd lie down and put her head on her paws, she still seemed ready to jump up and recite Chaucer, if that's what was asked. I don't usually say goodbye to animals—they don't know what it means; but when I said goodbye to Chaser, I'm pretty sure she understood.

DOGS ARE MORE LIKELY TO LISTEN ATTENTIVELY TO HUMAN SPEECH WHEN THE TOPIC AT HAND IS INTERESTING TO THE DOG.

rewil

IMAGINING THE LIVES OF DOGS IN A POST-HUMAN WORLD

BY JESSICA PIERCE, PHD

ding

ON A recent afternoon at the local dog park, a small group of human friends shared funny stories about how unwild their canine companions are. Poppy, her owner said, will stalk leaves and paper bags blowing down the sidewalk on windy days. Kaya always barks ferociously at the decorative gnome standing sentry in one of the local gardens. Nell flees in terror from the neighbor's cat, who simply wants to make friends. Bruno refuses to go outside when it is raining.

Poppy's owner sighs and says, "She'd never survive without me."

Dog park jokes about the questionable survival skills of our beloved fur balls are amusing. But behind the amusement lurks an interesting line of scientific inquiry: If we suddenly disappeared from the scene, would dogs disappear too? Would our furry friends be able to survive on their own, without our support and encouragement and without the daily provision of a bowl of kibble and a soft bed? Would dogs perish, or would they tap into some hidden wild reserves? And who would they become over time?

In our recent work and forthcoming book, *A Dog's World*, cognitive ethologist Marc Bekoff, PhD, and I embarked on a biological thought experiment along these lines. What might happen if, after 20,000-odd years of dog domestication, the process stopped and dogs began to rewild. We explored whether dogs would survive on their own and, using evolutionary theory and the growing body of research on free-ranging dogs, spun some possible evolutionary trajectories for canines in a humanless future. What we found might surprise you; it certainly surprised us.

After putting our heads together, we found it likely that dogs would survive and even thrive in a post-human world. And here, in a nutshell, is why: Like all canids, dogs are behaviorally flexible, versatile and opportunistic (a term used by biologists to mean that an organism can tolerate a wide variety of environmental conditions and will quickly take advantage of favorable conditions when they arise). Dogs retain many of the traits and behaviors of their wild relatives. Thanks to their genome, they still know, intuitively, how to forage, hunt, have sex, raise young, get along in groups, and defend themselves and their territory. As a species, dogs have not "forgotten" how to do these things, even though individual pet dogs may not have been raised in such a way that they can utilize these skills very effectively. Pet dogs may lack physical fitness and psychological resilience, and they are rarely able to learn "survival" skills from their canine mothers or fathers, as they would in the wild.

Yet dogs have been one of the most successful mammals on the planet, judging by their numbers and their global distribution. The billion-strong population of dogs inhabits all corners of the globe and successfully occupies diverse ecological niches, from deserts to urban metropolises to high Tibetan plateaus. A relatively small percentage of the world's dogs—somewhere between 15% and 20%—live within human homes as pets. The other 80% to 85% are already living on their own as free-ranging dogs—an umbrella term for feral, village, street and community dogs that are not "homed" or privately owned as pets. These free-ranging dogs do not depend directly upon humans for social companionship, veterinary care, emotional support or mental stimulation, yet nearly all of them depend, to a greater or lesser degree, on human food subsidies, which is a fancy way of saying that they eat our trash, waste (yes, that means feces) and handouts.

The first years after human disappearance would be hard for dogs as human food subsidies dried up. There would likely be significant die-offs. But dogs are flexible and highly adaptable. Being dietary generalists, dogs could survive on a wide range of foods, from plants, berries and insects to small mammals and birds and maybe even some larger prey. Exactly what dogs would try to eat would depend on where they live, their size, their body shape (are they small and short-limbed and able to dig and fit down a hole? Or are they long-limbed and lithe and able to run fast and catch prey above ground?) What and how

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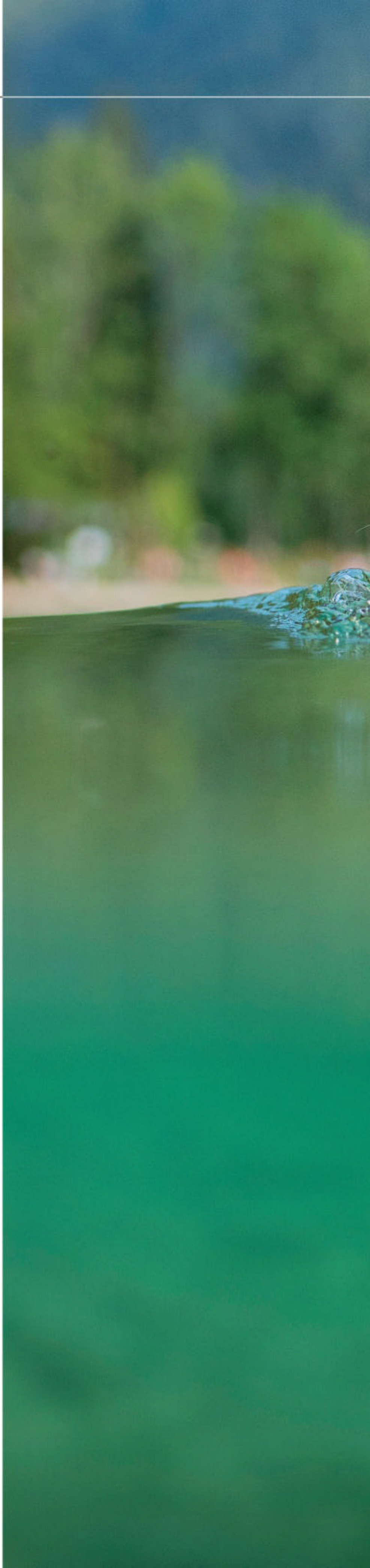
THANKS TO THEIR GENOME, DOGS INTUITIVELY KNOW HOW TO HAVE SEX AND RAISE THEIR YOUNG.



IN THE FUTURE, SOME DOGS MAY EVOLVE TO LIVE NEAR THE WATER AND BENEFIT FROM THE BOUNTY OF LAKES.

dogs eat will greatly influence how they evolve over time—and it could be that dogs will eventually evolve into several new species, using different feeding strategies to fill different ecological niches.

The key challenge for post-human-era dogs will be getting food. Another challenge will be surviving in climates and geographical areas for which they are ill-suited. A Chihuahua will have a hard time surviving in Juneau, Alaska, without humans to provide protection from the elements, as will a husky in Phoenix. The geographical distribution of dogs will shift and shrink, with populations concentrating in ecosystems and climates where they can best survive without human support. The new demands of being on their own will require a mixture of behavioral, neural, anatomical and physiological adaptations as well as a healthy dose of luck.

The Rewilding of Reproduction

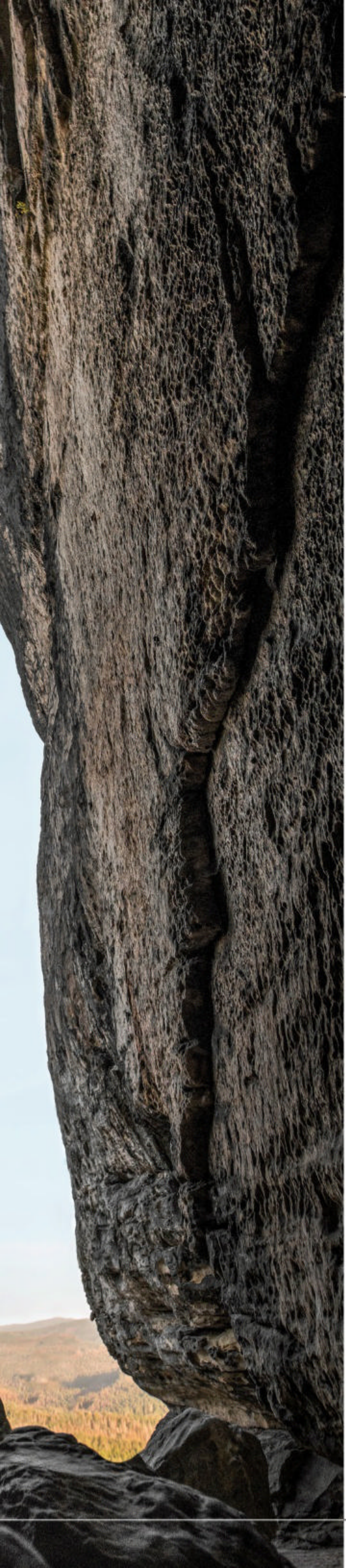
What dogs eat and what species they mate with are the most critical variables influencing whether dogs survive without us and what becomes of them over time. Without food, of course, individuals will die. Without reproduction, *Canis lupus familiaris*, as a species, will peter out. Post-human dogs will have to satisfy these two basic needs on their own, without human help or interference.

It's likely that dogs will adapt to a life without food subsidies over time, but reproduction could prove a greater challenge. Thinking about the reproductive lives of dogs sans humans takes us beyond questions of mere survival and into the heart of what dogs might ultimately become on their own, over the next 20, 200, 2,000, even 20,000 years and beyond.

Humans currently interfere in the reproductive lives of dogs in myriad ways. We control (or try to control) which dogs get to reproduce and when; which dogs will be reproductively neutralized and why; and which physical and behavioral traits will be emphasized. The rewilding of canine reproduction will likely usher in some dramatic changes to how dogs look and how they behave. During the first years after human disappearance, the millions of dogs who had been neutered or spayed will see their genetic future fizzle out. After the first generation, there would be no more "purebred" dogs, unless by sheer coincidence, and every dog would be a mutt. Dogs might even mate with wolves, coyotes or jackals, giving rise to hybrids.

Dogs have been selectively bred by humans for certain physical traits, including the shape and position of ears, the length of tails, and growth patterns and coloration of fur. We've selected for certain behavioral traits, including a general propensity for friendliness and malleability, and breed-specific functional skills, such as pointing, fetching, herding and guarding. While selection for these traits has been driven by human tastes and pursuits, it could be that in the wild, some of these qualities could serve dogs well. But other traits will likely be downright maladaptive, a hindrance to dogs' survival, and will disappear relatively quickly. For example, natural selection will quickly weed out extremely foreshortened snouts, which inhibit the ability of dogs to breathe, and excessive skin

SOME DOGS MAY MATE WITH WOLVES, COYOTES OR JACKALS, PRODUCING A POPULATION OF HYBRIDS.



AFTER A SINGLE GENERATION WITHOUT US, EVERY DOG ON EARTH WOULD BE A MUTT.

folds, which often become infected and require human maintenance. The health and behavioral problems linked to overbreeding—such as dysplasia, an unusual growth of cells, in shepherd dogs—will likely fade over time as the gene pool becomes more mixed and more robust.

With no humans, dogs will eventually look different from current dogs as their physical form evolves in response to the pressures of natural rather than human selection. However, exactly how the physical appearance of dogs might change over time is a surprisingly difficult question to answer, in part because there is enormous diversity in how dogs look and in how physical form influences behavior right now. Body sizes and shapes that impede survival in the wild will disappear, and dogs will develop bodies with physical traits—such as ears, noses and coats—that are best suited for the specific demands of climate and feeding strategies, at the very least.

It may be that dogs will eventually all become medium size and reddish in color, with medium-length noses and medium-size, upright ears—rather like current-day Australian dingoes. It could also be that dogs will form separate species over time, with some becoming smaller canids and others becoming larger-sized. Dogs living in hot desert climates might evolve big ears, like the fennec fox has, to help them dissipate body heat. Dogs living in northern latitudes might evolve thick fur, small ears and large feet.

Lonely Without Us?

For those of us in a committed relationship with a dog, it may be painful to imagine our canine companion living naked and alone in the wilderness, wondering why we have abandoned them. And surely, individual pet dogs who are strongly bonded to a particular human would suffer emotionally from the loss of their attachment figure. Still, the dogs of the future, who never knew humans, would likely do just fine without our friendship. This isn't to say that dogs don't enjoy their close association with us: Companion to humans is a pivotal role dogs have filled, and they have done it with a grace and skill that boggles the mind and heart. But a dog's purpose is not to be our loyal sidekick; this is not the only or even the ultimate role that dogs are fated to play in our earthly drama. In a post-human future, the canine show would go on. 🐾

Jessica Pierce, PhD, is a bioethicist and ethologist. Her forthcoming book, with animal behaviorist and cognitive ethologist Marc Bekoff, PhD, is A Dog's World: Imagining the Lives of Dogs in a World Without Humans.

accounting for personality

CANINE LOVERS TEND TO BE ESPECIALLY EXTROVERTED, AGREEABLE AND CONSCIENTIOUS BUT NOT AS OPEN TO NEW IDEAS AS FELINE FANS. IN THE DOG VS. CAT WARS, WHERE DO YOU STAND?

BY JILLIAN BLUME

ARE YOU a cat person or a dog person? Asked on a first date or when meeting a new potential friend, this question offers a more telling glimpse into personality than asking someone their sign. The answer may even green-light (or red-light) the second date.

If you're wondering if there really is a difference between dog people and cat people, you're not alone. Sam Gosling, PhD, a professor of psychology at the University of Texas, has asked the dog-person-or-cat-person question, and as a personality and social psychologist, has brought true rigor to the task.

Approaching the topic, Gosling found that the eternal question had been bandied about for years. One blogger, for instance, called dog people loyal, direct, kind, faithful, utilitarian and helpful. They were team players. On the other hand, she saw cat people as graceful, subtle, smart and mysterious. Any truth to the assessment? Gosling would let science weigh in. One study he cites, published back in 2007, found that dog people were "less hostile and less submissive" than cat people,

the five traits of dog people

Personality, for all of us, tends to fall along a spectrum of five different measurements. The Big Five personality traits model is currently one of the most established and accepted scientific approaches used to describe and measure individual differences in personality. The traits are listed below.

1 **EXTROVERSION** is defined by positive emotions, such as sociability and the tendency to seek out stimulation and new experiences. Extroverted people are comfortable with—and look forward to—meeting new people. They tend to be talkative and initiate conversation. Extroverts are assertive in their opinions and expressive about their emotions. Dog people measure high here. (The opposite of extroversion is introversion.)

2 **AGREEABLENESS** measures, "essentially, how sympathetic, warmhearted, trustworthy and trusting somebody is versus people who are more critical, less sentimental and less sympathetic," says professor of psychology Sam Gosling. Agreeableness also describes an individual's level of cooperativeness and compassion. Dog folks have this trait in abundance. (The opposite of agreeableness is antagonism.)

3 **CONSCIENTIOUSNESS** is a trait "essentially associated with our frontal lobes," says Gosling. Those high in this trait are punctual and organized, and they tend to follow rules. People low on conscientiousness tend to be more chaotic and disorganized. Stanley Coren, a psychology professor, neuropsychological researcher and recognized expert on dog-human interaction, adds that the trait reveals a tendency "to show self-discipline, to complete tasks and aim for achievement. The trait shows a preference for planned rather than spontaneous behavior." There's so much detail involved in dog care, you'd better be conscientious, in spades. (The opposite of conscientiousness is lack of direction.)

4 **NEUROTICISM** manifests as anxiety, moodiness, self-doubt, irritability and emotional instability. People who score low on neuroticism (i.e., dog people) are more emotionally stable, easygoing and relaxed. (The opposite is emotional stability.)

5 **OPENNESS** measures openness to ideas. People high in this personality trait (typically, cat people) are more philosophical and creative, says Gosling. They have more imagination and insight, whereas those lower in the trait tend to be more traditional and conventional and generally don't appreciate abstract or theoretical concepts, Gosling says. (The opposite is closed-mindedness. On the spectrum of this trait, dog folks were clustered here.)

which makes sense, considering the nature of dogs. It's harder to be hostile when looking at the smiling, panting face of a goofy pup.

Gosling himself has been collecting data on human personality since the 1990s, creating surveys using The Big Five Inventory, the most widely used standard to measure personality. For his research into the differences between dog and cat people, he added a question about identifying as a dog person or a cat person at the end of a survey that was framed as a broad personality test, thereby preventing any preconceived bias that might affect the results.

The Dog Person(ality)

Everyone falls somewhere along the spectrum on each of the five personality traits studied by Gosling (see sidebarpage 95), and dog lovers are no exception. Of 4,565 people queried in his study, it turned out that 2,088 self-identified as dog people. They were, in general, significantly more extraverted, agreeable and conscientious than cat people but were less open and less neurotic. Of those studied, there were 1,264 subjects who identified as both dog and cat people and 686 who claimed to be neither.

The results make sense. Dog people, whom you see out in the streets in force, are propelled by their extraversion and agreeableness to socialize at dog parks, attend dog events and, often, to stop and chat with complete strangers who are also walking their dogs. On the other hand, in a related study by animal behaviorist Stanley Coren, PhD, cat owners were likelier to live alone and tended to prefer solitude. While dog people thrive in a social milieu, cat people often find social interaction draining.

"Because dogs are generally more sociable than cats, dog lovers would naturally be higher in sociability," Coren writes. While dog people tend to feel empathy for others, some cat people may have less interest in other people's problems, some of the research suggests.

But being a dog person is not all fun and games. The dog person must often meet a higher standard for organized care of their fur friend than their cat person counterpart. So conscientiousness is key. Since dogs go outside and many cats don't, dog walks often require having a schedule, doing some planning and organizing the appropriate supplies. In contrast, cat owners dislike structure and schedules; they don't have to plan for their cat's walks because cats use their litter box whenever they want.

HEAD-TO-HEAD: 74% OF PEOPLE LIKED DOGS AND 41% CATS, ACCORDING TO A POLL BY THE ASSOCIATED PRESS.

It's no wonder that dog people, with all these strengths, also score high on quality of emotional stability and low on neuroticism. Since dogs are so attuned to their humans' emotions, dog owners must be emotionally in touch to fill their companion role. Dogs generally need social interaction in order to be happy and will intrude on their human for attention or when they want company. Dogs accept their humans exactly as they are, leading dog people to be themselves. And because your dog thinks you're the most amazing biped to ever walk the Earth, dogs can boost your confidence too. Dogs are also natural-born comedians, and living with them is good for humans' mental health.

Cat people, like many cats, tend to be more dramatic and easily thrown off kilter, Gosling notes. They are moodier, more temperamental and more introspective, which correlates with the Big Five trait of openness—an attraction to mystery and exploration of the unknown. Dogs are more "what you see is what you get." Cats stay at home, weaving their spells and incantations, while dogs are out in the fields, pulling up root vegetables and rolling in the mud.

When you come home after a long day at work, a dog is likelier to shower you with kisses and then fetch your slippers. "Cats, on the other hand, are often invisible during the day, seeming only to appear in the evening, especially if that is when they are fed," writes Coren. "Cats will occasionally engage in social activities or play with people, but their interest is limited," leaving more space for the cat person and the cat to coexist on parallel planes.

Personality traits comprising the Big Five are useful because they can be applied to people in different cultures and across ethnicities. But, Gosling emphasizes, they paint personality with broad strokes. "Lots of things go into personality," Gosling says. The Big Five traits are only part of it. "The traits indicate tendencies to behave a certain way, but that doesn't include things like our values, goals, attitudes or...identity." When people self-identify as a dog person or cat person, he adds, that alone says a lot about who they are.

If you're wondering, Gosling doesn't have a pet, because he travels too much—but if he had one, he says, it would be a dog. 🐾

SPENDING TIME IN NATURE CAN BE ENRICHING FOR SOME BREEDS.

SPECIAL EDITION

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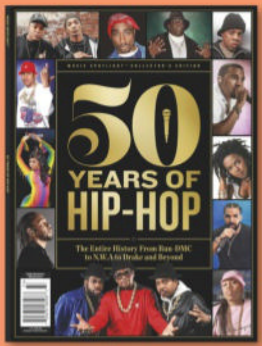
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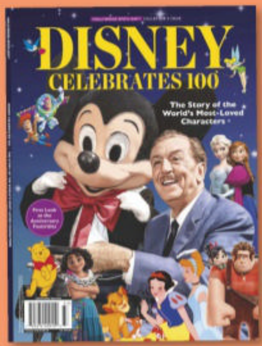
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